Tracing-error signal detection device and regnerated signal detection apparatus

Publication number: CN1300054
Publication date: 2001-06-20

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Classification:
- international: *G11B7/005; G11B7/09; G11B7/13;* **G11B7/00; G11B7/09; G11B7/13;** (IPC1-7): G11B7/00; G11B7/09; G11B21/10
- european: G11B7/005; G11B7/09G; G11B7/13B
Application number: CN20001034725 20001030
Priority number(s): KR19990047750 19991030

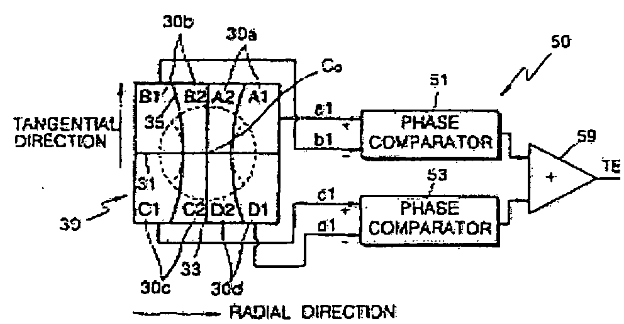
Also published as:

- EP1096481 (A2)
- US6584049 (B1)
- JP2001155354 (/
- EP1096481 (A3)
- CN1193351C (C)

Abstract not available for CN1300054
Abstract of corresponding document: **EP1096481**

There are provided a tracking error signal detecting apparatus with improvement in offset due to gain characteristics and/or a difference in the depth between pits by providing an improved sectioning structure of an 8-sectional photodetector (30) having inner and outer sectional plates (A2, B2, C2, D2; A1, B1, C1, D1), the radial widths of which vary along +- tangential directions from the center of the photodetector (30), and a reproduction signal detecting apparatus with reduced crosstalk noise. Therefore, the tracking error signal detecting apparatus can allow accurate tracking control in a high-density recording medium having relatively narrow tracks. Also, the reproduction signal detecting apparatus can correct signal distortion due to a difference between phase characteristics of detection signals of inner and outer sectional plates of a photodetector (30) even during reproduction of an information signal from a high-density recording medium having relatively narrow tracks, thereby detecting an improved reproduction signal with greatly reduced crosstalk.

FIG. 4



Tracing-error signal detection device and regnerated signal detection apparatus

Description of corresponding document: **EP1096481**

[0001] The present invention relates to a tracking error signal detecting apparatus and a reproduction signal detecting apparatus, and more particularly, to a tracking error signal detecting apparatus for improving the precision in detecting a tracking error signal and a reproduction signal detecting apparatus for detecting a reproduction signal with crosstalk noise greatly reduced.

[0002] Conventional methods for detecting tracking errors by receiving light radiated from a light source of an optical pickup device and reflected from a disk include a method for detecting a tracking error signal (TES) by differential phase detection (DPD).

[0003] Referring to Figure 1, light radiated onto a ROM-type disk is reflected and is diffracted into 0th-order maximum and +/-1st-order maxima by recording marks such as pits (P). After traveling back through the optical pickup, the light received at a photodetector 1 substantially consists of the 0th-order maximum overlapped by +/-1st-order maxima in a radial direction. Here, in the case of a high-density disk having narrow tracks, such as a next-generation digital versatile disk (DVD), which is called a HD-DVD, the 0th-order maximum and +/-1st-order maxima overlap, while +1st-order maximum and -1st-order maximum do not overlap each other.

[0004] Phase signals of portions where the 0th-order maximum and the +1st-order maximum overlap and where the 0th-order maximum and the -1st-order maximum overlap have different features from a phase signal of the 0th-order maximum only. Thus, in the case of the high-density disk having narrow tracks, if a tracking error signal is detected by a general DPD method in which detection signals of diagonal sectional plates A/C and B/D are simply subtracted, great noise is caused in the tracking error signal due to crosstalk between adjacent tracks.

[0005] In order to detect a tracking error signal with reduced crosstalk noise from adjacent tracks, there has been proposed a method in which an 8-sectional photodetector 20 is employed, as shown in Figure 2.

[0006] The 8-sectional photodetector 20 is divided into 4 parts in a row direction corresponding to the radial direction of a disk and is divided into 2 parts in a column direction corresponding to the tangential direction of a disk, so that its sections are arranged in a 2 x 4 matrix. Here, the respective 2-sectional plates A1/A2, B1/B2, C1/C2 and D1/D2 correspond to the sectional plates A, B, C and D of the photodetector 20 shown in Figure 1. The sectional plates A2, B2, C2 and D2 are positioned at the inner sides of A1, B1, C1 and D1, respectively.

[0007] The tracking error signal is produced from detection signals of the 8-sectional photodetector 20 as follows.

[0008] Referring to Figure 3, a sum signal (a1+c1) of detection signals a1 and c1 of outer sectional plates A1 and C1 arranged in a diagonal direction and a signal obtained by amplifying a sum signal (a2+c2) of detection signals a2 and c2 of inner sectional plates A2 and C2 with a predetermined gain k1 are summed, and the sum signal [a1+c1+k1(a2+c2] is input to an amplifier 21 to then be amplified with a predetermined gain k2. Likewise, a sum signal (b1+d1) of detection signals b1 and d1 of outer sectional plates B1 and D1 arranged in another diagonal direction and a signal obtained by amplifying a sum signal (b2+d2) of detection signals b2 and d2 of inner sectional plates B2 and D2 with a predetermined gain k are summed. Then, the signal [k2(a1+c1+k1(a2+c2))] output from the amplifier 21 and the operation signal [b1+d1+k(b2+d2)] output from the diagonal sectional plates B1, B2, D1 and D2 are applied to a phase comparator 25 for comparison of phases, to then generate a tracking error signal TES'.

[0009] Here, if k=k1=0 and k2=1, the signals applied to the phase comparator 25 are a1+c1 and b1+d1, which corresponds to the case where a phase difference is obtained using a sum signal of detection signals of outer sectional plates arranged in a diagonal direction.

[0010] Also, if k NOTEQUAL 0 and k1 NOTEQUAL 0, the signals applied to the phase comparator 25 are a2+c2 and b2+d2, which corresponds to the case where a phase difference is obtained using a sum signal of detection signals of inner sectional plates arranged in a diagonal direction.

[0011] According to the aforementioned tracking error signal detecting apparatus, since a phase difference is obtained by selectively amplifying detection signals of inner sectional plates A2, B2, C2 and D2 with a predetermined gain factors and then adding the amplified signals and detection signals of outer sectional plates A1, B1, C1 and D1, a tracking error signal with reduced crosstalk noise can be generated.

[0012] Although the conventional tracking error signal detecting apparatus reduces crosstalk noise to a degree, when it is employed with a high-density disk having narrow tracks, in which tangential phase characteristics are obscured, the gain of tracking error signals is very low, that is, the precision is poor.

[0013] The beams received at sectional plates positioned at different locations in a tangential direction of a track have different phase characteristics at a starting area and an ending area of a recording mark such as a pit. However, if detection signals of diagonally adjacent plates are summed like in the conventional tracking error signal detecting apparatus, tangential phase characteristics are offset, which results in tracking error signals having a low gain, that is, poor precision.

[0014] Also, in the conventional tracking error signal detecting apparatus, since sum signals of detection signals of diagonally adjacent sectional plates are used, a phase difference between the sum signals is offset due to a difference in the depth between pits. Thus, if an objective lens (not shown) is shifted, a large offset may occur to the tracking error signals.

[0015] The present invention has been made in view of the points described above, and it is an aim of embodiments of the present invention to provide a tracking error signal detecting apparatus with improvement in gain characteristics and/or offset due to a difference in the depth between pits by providing an improved sectioning structure of an 8-sectional photodetector, and a reproduction signal detecting apparatus with reduced crosstalk noise.

[0016] According to a first aspect of the invention, there is provided a tracking error signal detecting apparatus including a photodetector for receiving light reflected/diffracted from a recording medium, and a circuit unit for performing operations on detection signals of the photodetector and producing a tracking error signal, the apparatus characterized in that the photodetector includes four light receiving regions arrayed counterclockwise, the dividing lines of which are substantially parallel to the radial and tangential directions of the recording medium, each of the four light receiving regions are further bisected to produce an inner sectional plate and an outer sectional plate, the radial widths of which vary along +/- tangential directions from the center of the photodetector, so that 8 inner and outer sectional plates arrayed in a 2 x 4 matrix are formed, the directions of columns and rows of the sectional plates corresponding to the radial and tangential directions of the recording medium, and the circuit unit compares the phases of the light receiving regions positioned in the same row and then produces a tracking error signal from a phase difference signal.

[0017] Preferably, the circuit unit amplifies at least some of the detection signals of the inner and/or outer sectional plates positioned in one diagonal direction with a predetermined gain, compares phase differences between the amplified signals and at least some of the detection signals of inner and/or outer sectional plates positioned in the other diagonal direction, and detects a tracking error signal from a phase difference signal.

[0018] Preferably, the inner sectional plates are formed such that their widths are relatively narrower at the center of the photodetector and relatively wider along +/- tangential directions.

[0019] For example, the lines dividing the inner light receiving regions from the outer sectional plates are preferably curved lines, and the maximum width of each of the inner sectional plates is preferably larger than the radius of received 0th-order diffracted light.

[0020] The reproduction signal detecting apparatus may include a photodetector for receiving light reflected/diffracted from a recording medium, and a circuit unit for performing operations on detection signals of the photodetector and producing a reproduction signal, the photodetector includes four light receiving regions arrayed counterclockwise, the dividing lines of which are substantially parallel to the radial and tangential directions of the recording medium, each of the four light receiving regions are further bisected to produce an inner sectional plate and an outer sectional plate, the radial widths of which vary along +/- tangential directions from the center of the photodetector, so that 8 inner and outer sectional plates arrayed in a 2 x 4 matrix are formed, the directions of columns and rows of the sectional plates corresponding to the radial and tangential directions of the recording medium, and the circuit unit includes an amplifier for amplifying a sum signal of detection signals of the outer sectional plates, and an adder for adding a sum signal of detection signals of the inner sectional plates and the output signal of the amplifier.

[0021] According to another aspect of the present invention, the circuit unit may further include a time delay for time-delaying detection signals of the inner and/or outer sectional plates positioned in one row.

[0022] Preferably, the circuit unit comprises: a first phase comparator for comparing phases of detection signals of a pair of outer sectional plates positioned in one row and outputting a phase difference signal; a second phase comparator for comparing phases of detection signals of a pair of outer sectional plates positioned in the other row and outputting a phase difference signal; and an adder for adding phase difference signals output from the first and second phase comparators and outputting a tracking error signal.

[0023] The circuit unit may comprise: a first phase comparator for comparing phases of detection signals of a pair of inner sectional plates positioned in one row and outputting a phase difference signal; a second phase comparator for comparing phases of detection signals of a pair of inner sectional plates positioned in the other row and outputting a phase difference signal; and an adder for adding phase difference signals output from the first and second phase comparators and outputting the tracking error signal.

[0024] The circuit unit may comprise: first and second phase comparators for comparing phases of detection signals of a pair of outer and inner sectional plates positioned in one row, respectively, and outputting phase difference signals; third and fourth phase comparators for comparing phases of detection signals of a pair of outer and inner sectional plates positioned in the other row, respectively, and outputting phase difference signals; a first adder for adding the phase difference signals output from the first and third phase comparators to detect a first tracking error signal based on the detection signals of the outer sectional plates; a second adder for adding the phase difference signals output from the second and fourth phase comparators to detect a second tracking error signal based on the detection signals of the inner sectional plates; and an operator for summing the first and second tracking error signals detected by the first and second adders to output a tracking error signal.

[0025] Preferably, the operator amplifies at least one of the first and second tracking error signals output from the first and second adders with a predetermined gain to produce a tracking error signal.

[0026] Preferably, the circuit unit comprises: a first operator for amplifying a detection signal of one inner sectional plate positioned in one row with a predetermined gain and adding the amplified signal and a detection signal of the corresponding outer sectional plate; a second operator for amplifying a detection signal of the other inner sectional plate positioned in one row with a predetermined gain and adding the amplified signal and a detection signal of the corresponding outer sectional plate; a third operator for amplifying a detection signal of one inner sectional plate positioned in the other row with a predetermined gain and adding the amplified signal and a detection signal of the corresponding outer sectional plate; a fourth operator for amplifying a detection signal of the other inner sectional plate positioned in the other row with a predetermined gain and adding the amplified signal and a detection signal of the corresponding outer sectional plate; a first phase comparator for comparing phases of sum signals output from the first and second operatorsand outputting a phase difference signal; a second phase comparator for comparing phases of sum signals output from the third and fourth operators and outputting a phase difference signal; and an adder for adding the phase difference signals output from the first and second phase comparators to output a tracking error signal.

[0027] Preferably, the inner sectional plates are formed such that their widths are relatively narrower at the center of the photodetector and relatively wider along +/- tangential directions.

[0028] Preferably, the lines dividing the inner light receiving regions from the outer sectional plates are curved lines.

[0029] Preferably, the maximum width of each of the inner sectional plates is larger than the radius of received 0th-order diffracted light.

[0030] Preferably, the width of each of the inner sectional plates linearly increases from the center of the photodetector outward in the +/- tangential directions.

[0031] Preferably, each of the inner sectional plates has a shape selected from a trapezoid, a right-angle triangle and an isosceles triangle.

[0032] According to another aspect, there is provided a tracking error signal detecting apparatus having a photodetector for receiving light reflected/ diffracted from a recording medium, and a circuit unit for performing operations on detection signals of the photodetector and producing a tracking error signal, the apparatus characterized in that the photodetector includes four light receiving regions arrayed counterclockwise, the dividing lines of which are substantially parallel to the radial and tangential

directions of the recording medium, each of the four light receiving regions are further bisected to produce an inner sectional plate and an outer sectional plate, the radial widths of which vary along +/- tangential directions from the center of the photodetector, so that 8 inner and outer sectional plates arrayed in a 2 x 4 matrix are formed, the directions of columns and rows of the sectional plates corresponding to the radial and tangential directions of the recording medium, and that the circuit unit amplifies at least some of the detection signals of the inner and/or outer sectional plates positioned in one diagonal direction with a predetermined gain, compares phase differences between the amplified signals and at least some of the detection signals of inner and/or outer sectional plates positioned in the other diagonal direction, and detects a tracking error signal from a phase difference signal.

[0033] The circuit unit may comprise: an amplifier for amplifying a sum signal of detection signals of outer or inner sectional plates positioned in one diagonal direction with a predetermined gain; and a phase comparator for comparing phases of a sum signal of detection signals of outer or inner sectional plates positioned in the other diagonal direction to detect a tracking error signal.

[0034] The circuit unit may comprise: a first operator for receiving detection signals of inner and outer sectional plates positioned in one diagonal direction, amplifying a sum signal of detection signals of the inner sectional plates with a first predetermined gain and adding the amplified signal and a sum signal of detection signals of the outer sectional plates; a second operator for receiving detection signals of inner and outer sectional plates positioned in the other diagonal direction, amplifying a sum signal of detection signals of the inner sectional plates with a second predetermined gain and adding the amplified signal and a sum signal of detection signals of the outer sectional plates; an amplifier for amplifying a signal output from one of the first and second operators with a third predetermined gain; and a phase comparator for comparing phases of a signal output from the other of the first and second operators and a signal output from the amplifier to produce a tracking error signal.

[0035] The sum of the first and second predetermined gains is preferably a constant value.

[0036] The circuit unit may further comprise a time delay for time-delaying detection signals of the inner and/or outer sectional plates positioned in one row.

[0037] The inner sectional plates may be formed such that their widths are relatively narrower at the center of the photodetector and relatively wider along +/- tangential directions.

[0038] Preferably, the lines dividing the inner light receiving regions from the outer sectional plates are curved lines.

[0039] Preferably, the maximum width of each of the inner sectional plates is larger than the radius of received 0th-order diffracted light.

[0040] Preferably, the width of each of the inner sectional plates linearly increases from the center of the photodetector outward in the +/- tangential directions.

[0041] Preferably, each of the inner sectional has a shape selected from a trapezoid, a right-angle triangle and an isosceles triangle.

[0042] In another aspect, there is provided a reproduction signal detecting apparatus having a photodetector for receiving light reflected/ diffracted from a recording medium, and a circuit unit for performing operations on detection signals of the photodetector and producing a reproduction signal, the apparatus characterized in that the photodetector includes four light receiving regions arrayed counterclockwise, the dividing lines of which are substantially parallel to the radial and tangential directions of the recording medium, each of the four light receiving regions are further bisected to produce an inner sectional plate and an outer sectional plate, the radial widths of which vary along +/- tangential directions from the center of the photodetector, so that 8 inner and outer sectional plates arrayed in a 2 x 4 matrix are formed, the directions of columns and rows of the sectional plates corresponding to the radial and tangential directions of the recording medium, and that the circuit unit comprises: an amplifier for amplifying a sum signal of detection signals of the outer sectional plates; and an adder for adding a sum signal of detection signals of the inner sectional plates and the output signal of the amplifier.

[0043] The circuit unit may further comprise a time delay for time-delaying detection signals of the inner and/or outer sectional plates positioned in one row.

[0044] The respective light receiving regions may be bisected such that the width of each of the inner sectional plates linearly increases from the center of the photodetector outward in the +/- tangential directions.

[0045] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 is a perspective view illustrating light reflected/diffracted from a general recording medium;
Figures 2 and 3 illustrate a tracking error signal detecting apparatus employing a conventional 8-sectional photodetector;
Figure 4 is a diagram schematically illustrating a tracking error signal detecting apparatus according to an embodiment of the present invention;
Figure 5 through 8 are plan views schematically illustrating another example of a photodetector shown in Figure 4;
Figure 9 is a graph showing tracking error signals output from the tracking error signal detecting apparatus shown in Figure 4;
Figure 10 is a graph showing tracking error signals output from the conventional tracking error signal detecting apparatus;
Figures 11 through 13 are block diagrams illustrating another example of a circuit unit shown in Figure 4;
Figure 14 is a diagram schematically illustrating a tracking error signal detecting apparatus according to another embodiment of the present invention;
Figures 15 through 17 are block diagrams illustrating another example of a circuit unit shown in Figure 14;
Figure 18 is a diagram schematically illustrating a reproduction signal detecting apparatus according to an embodiment of the present invention; and
Figure 19 is a diagram schematically illustrating a reproduction signal detecting apparatus according to another embodiment of the present invention.

[0046] Referring to Figure 4, a tracking error signal detecting apparatus according to an embodiment of the present invention includes a photodetector 30 for receiving the light reflected/diffracted from a recording medium such as a disk (10 of Figure 1), and a circuit unit 50 for performing operations with respect to detection signals of the photodetector 30 to produce a tracking error signal TES. Here, the photodetector 30 receives incident light which is reflected from the recording medium, and the detection signals thereof are used in detecting the tracking error signal TES and detecting a reproduction signal of the recording medium to be described later.

[0047] The photodetector 30 includes four light receiving regions 30a (A1/A2), 30b (B1/B2), 30c (C1/C2) and 30d (D1/D2) arrayed counterclockwise in a 2x2 matrix, the light receiving regions being produced such that the photodetector 30 is bisected in a direction corresponding to the tangential direction of the recording medium and further bisected in a direction corresponding to the radial direction of the recording medium, where the tangential direction refers to a direction of information sequences recorded on the recording medium and the radial direction refers to a direction perpendicular to the information sequences. The respective light receiving regions 30a, 30b, 30c and 30d are bisected to have inner sectional plates A2, B2, C2 and D2, the radial widths of which vary along the +/- tangential directions from the center C0 of the photodetector 30.

[0048] Thus, the photodetector 30 is arrayed in 2x4 matrix and consists of 8 sectional plates A1, A2, B1, B2, C1, C2, D1 and D2 for independently performing photoelectric conversion. The outer sectional plates A1, B1, C1 and D1 and the inner sectional plates A2, B2, C2 and D2 are arranged counterclockwise.

[0049] As shown in Figure 2, the light reflected/diffracted from a ROM-type high-density recording medium having relatively narrow tracks is diffracted into 0th-order diffracted light and +/-1st-order diffracted light along the radial direction. When the 0th-order diffracted light and the +/-1st-order diffracted light overlap and +1st-order diffracted light and -1st-order diffracted light do not overlap, the outer sectional plates A1, B1, C1 and D1 receive light mainly from the overlapping area of the 0th-order diffracted light and the +1st-order diffracted light and from the overlapping area of the 0th-order diffracted light and the -1st-order diffracted light, and the inner sectional plates A2, B2, C2 and D2 receive light only from the area of the 0th-order diffracted light.

[0050] In other words, the inner sectional plates A2, B2, C2 and D2 are preferably formed such that the widths thereof are relatively narrow at the center C0 of the photodetector 30 and become wider along the +/- tangential directions.

[0051] However, in the case of employing a low-density recording medium having a relatively large track pitch or RAM-type high-density recording medium having a land/groove configuration, in which some of +/-1st-order diffracted light reflected/diffracted from the recording medium simultaneously overlap with 0th-order diffracted light, the respective light receiving regions 30a, 30b, 30c and 30d are preferably bisected

to have inner sectional plates A2, B2, C2 and D2, the widths of which are relatively wide at the center C0 of the photodetector 30 and become narrower along the +/- tangential directions. Here, the inner sectional plates A2, B2, C2 and D2 receive the light from an area where the 0th-order diffracted light and the +/-1st-order diffracted light overlap simultaneously.

[0052] The sectioning structure of the 8-sectional photodetector 30 according to the present invention will now be described through detailed embodiments. As shown in Figures 4 and 5, a dividing line 35 of each of the respective light receiving regions 30a, 30b, 30c and 30d is preferably a curved line having a predetermined curvature so as to separately receive light from an area of the 0th-order diffracted light and an overlapping area of the 0th-order diffracted light and the +/-1st-order diffracted light.

[0053] Here, the dividing line 35 is tangent to the overlapping area of the 0th-order diffracted light and the +/-1st-order diffracted light at the intersection with a row-directional dividing line 31.

[0054] Figure 4 illustrates that the dividing line 35 is substantially a part of an ellipse, and Figure 5 illustrates that the dividing line 35 is a part of a parabola formed such that the maximum width of each of the inner sectional plates A2, B2, C2 and D2 is greater than the radius of the 0th-order diffracted light received thereat. The dividing line 35 shown in Figure 5 more closely fits the boundary of the overlapping area of the 0th-order diffracted light and the +/-1st-order diffracted light and thus has an advantage in that it can minimize the amount of 0th-order diffracted light received at the outer sectional plates A1, B1, C1 and D1.

[0055] Alternatively, the respective light receiving regions 30a, 30b, 30c and 30d may be bisected such that the width of each of the inner sectional plates A2, B2, C2 and D2 linearly increases from the center C0 of the photodetector 30 outward in the +/- tangential directions.

[0056] For example, the respective light receiving regions 30a, 30b, 30c and 30d may be bisected such that each of the inner sectional plates A2, B2, C2 and D2 has the shape of a trapezoid, a right triangle or an isosceles triangle, as viewed at positions spaced a predetermined distance apart from the center C0 of the photodetector 30 outward in the +/- tangential directions, as shown in Figures 6 through 8.

[0057] The tracking error signal detecting apparatus according to an embodiment of the present invention employs the 8-sectional photodetector 30 having various sectioning configurations as described above, and the photodetector 30 having the sectioning configuration shown in Figure 4 will be described below by way of example.

[0058] Referring back to Figure 4, the circuit unit 50 compares the phases of detection signals of inner and/or outer sectional plates positioned in the same row with each other and detects a tracking error signal from phase difference signals.

[0059] For example, as shown in Figure 4, the circuit unit 50 includes a pair of phase comparators 51 and 53 for comparing phases of input signals, and an adder 59 for adding phase difference signals output from the phase comparators 51 and 53.

[0060] Detection signals a1 and b1 of the outer sectional plates A1 and B1 positioned in the first row are input to the phase comparator 51 for phase comparison. Detection signals c1 and d1 of the outer sectional plates C1 and D1 positioned in the second row are input to the phase comparator 53 for phase comparison.

[0061] Thus, a tracking error signal TES output from the adder 59 is obtained by adding a phase difference signal between the detection signals a1 and b1 of the outer sectional plates A1 and B1 and a phase difference signal between the detection signals c1 and d1 of the outer sectional plates C1 and D1 positioned in the same row, that is, in the same row in the tangential direction, the phase difference signals being applied from the phase comaprators 51 and 53, respectively.

[0062] Figure 9 is a graph showing a tracking error signal TES detected from the circuit unit 50 of the tracking error signal detecting apparatus according to an embodiment of the present invention, shown in Figure 4, and Figure 10 is a graph showing a tracking error signal TES' generated by the conventional tracking error signal detecting apparatus shown in Figures 2 and 3. Here, the abscissa indicates a light spot moving across tracks of a recording medium in a radial direction, and the ordinate indicates a change in the tracking error signal depending on the movement of a light spot.

[0063] Comparing Figures 9 and 10, the tracking error signal TES detected by the tracking error signal detecting apparatus according to the present invention has a large gain and noticeably improved noise characteristics, compared to the tracking error signal TES' generated by obtaining the diagonal sum

signals a1+c1 and b1+d1 of the detection signals a1, b1, c1 and d1 of the outer sectional plates A1, B1, C1 and D1 of the conventional photodetector (20 of Figure 2) and then comparing the phases thereof.

[0064] In another embodiment of the circuit unit 50, as shown in Figure 11, the tracking error signal may be generated using the detection signals a2, b2, c2 and d2 of the inner sectional plates A2, B2, C2 and D2, instead of the detection signals a1, b1, c1 and d1 of the outer sectional plates A1, B1, C1 and D1.

[0065] In other words, detection signals a2 and b2 of the inner sectional plates A2 and B2 positioned in the first row are applied to a phase comparator 151 and a phase difference signal is output therefrom. Also, detection signals c2 and d2 of the inner sectional plates C2 and D2 positioned in the second row are applied to another phase comparator 153 and a phase difference signal is output therefrom. An adder 159 adds the phase difference signals and outputs a tracking error signal.

[0066] In a still another embodiment, the circuit unit 50, as shown in Figure 12, has a combined structure of the configurations shown in Figures 4 and 11, to detect a tracking error signal using detection signals a1, a2, b1, b2, c1, c2, d1 and d2 of all inner and outer sectional plates A1, A2, B1, B2, C1, C2, D1 and D2.

[0067] In other words, a tracking error signal TES1 (see Figure 9) obtained by an operation of the detection signals a1, b1, c1 and d1 of the outer sectional plates A1, B1, C1 and D1, and a tracking error signal TES2 obtained by an operation of the detection signals a2, b2, c2 and d2 of the inner sectional plates A2, B2, C2 and D2, are summed by an operator 60 to produce a tracking error signal TES. Here, the TES2 is a tracking error signal obtained by operation of the detection signals a2, b2, c2 and d2 of the inner sectional plates A2, B2, C2 and D2, and corresponds to a tracking error signal output from the adder 159 shown in Figure 11.

[0068] The operator 60 amplifies one tracking error signal TES2 of the tracking error signals TES1 and TES2 output from the adder 59 and 159 with a predetermined gain k and then sums the other tracking error signal TES1 and the amplified signal k*TES2 to produce a tracking error signal TES [=TES1+(k*TES2)].

[0069] Here, the operator 60 may amplify the tracking error signal TES1 with a predetermined gain. Otherwise, the operator 60 amplifies both the tracking error signal TES1 and TES2 with appropriate gains and then sums the amplified signals and produces the tracking error signal TES.

[0070] Alternatively, the circuit unit 50, as shown in Figure 13, may include first through fourth operators 161, 162, 163 and 164, first and second phase comparators 165 and 167 and an adder 169, and may produce a tracking error signal by phase-comparing sum signals a1+ka2, b1+kb2, c1+kc2 and d1+kd2 of signals ka2, kb2, kc2 and kd2 obtained by amplifying detection signals a2, b2, c2 and d2 of the inner sectional plates A2, B2, C2 and D2 with a predetermined gain k, and detection signals a1, b1, c1 and d1 of the corresponding outer sectional plates A1, B1, C1 and D1, and adding phase difference signals.

[0071] The detection signals a1 and a2 of the outer and inner sectional plates A1 and A2 forming the light receiving regions A1 and A2 positioned in the first row, are applied to the first operator 161. The first operator 161 amplifies the detection signal a2 of the inner sectional plate A2 with a predetermined gain k and then sums the same with the detection signal a1 of the outer sectional plate A1. Thus, output signal of the first operator 161 becomes a1+ka2.

[0072] Likewise, the detection signals b1 and b2, c1 and c2, and d1 and d2 of the other light receiving regions B1 and B2, C1 and C2, and D1 and D2 are applied to the second through fourth operators 162, 163 and 164 to then be operated. The second through fourth operators 162, 163 and 164 output operation signals b1+kb2, c1+kc2 and d1+kd2.

[0073] Signals detected from the light receiving regions A1 and A2, and B1 and B2 positioned in the first row and having passed through the first and second operators 161 and 162 are phase-compared by the first phase comparator 165. Likewise, signals detected from the light receiving regions C1 and C2, and D1 and D2 positioned in the second row and having passed through the third and fourth operators 163 and 164 are phase-compared by the second phase comparator 167.

[0074] The phase difference signals output from the first and second phase comparators 165 and 167 are summed by the adder 169. Then, the adder 169 outputs the tracking error signal TES.

[0075] The circuit unit 50 having the aforementioned configuration sums detections signals of outer and inner sectional plates forming the respective light receiving regions 30a, 30b, 30c and 30d with signals obtained by amplifying the detection signals of the inner sectional plates with a predetermined gain, and

phase differences of signals from the sectional plates positioned in the same row are compared. Thus, a difference in the signal characteristic between detection signals of the outer and inner sectional plates can be compensated for, thereby detecting a tracking error signal with a large gain and reduced crosstalk noise.

[0076] Figure 14 illustrates a tracking error signal detecting apparatus according to another embodiment of the present invention, in which a circuit unit 250 detects a tracking error signal from phase difference signals by amplifying at least some of the detection signals of inner and/or outer sectional plates positioned in one diagonal direction with a predetermined gain and phase-comparing the amplified signals with at least some of the detection signals of inner and/or outer sectional plates positioned in the other diagonal direction.

[0077] For example, as shown in Figure 14, the circuit unit 250 includes an amplifier 260 for amplifying a sum signal of the detection signals a1 and c1 of the outer sectional plates A1 and C1 positioned in one diagonal direction, and a phase comparator 251 for comparing phases of a sum signal b1+d1 of the detection signals b1 and d1 of the outer sectional plates B1 and D1 positioned in the other diagonal direction and an output signal k2(a1+c1) of the amplifier 260 to detect a tracking error signal TES. Here, the gain k2 is a constant other than zero.

[0078] The aforementioned tracking error signal detecting apparatus sums detection signals of outer sectional plates positioned in a diagonal direction like in the general DPD method. However, the apparatus receives only the light of overlapping areas of the 0th-order maximum and +1st-order maximum and the 0th-order maximum and -1st-order maximum from outer sectional plates, amplifies the sum signal of one diagonal direction with a predetermined gain and then compares the phase of the amplified signal with that of the sum signal of the other diagonal direction. Thus, the tracking error signal TES has a larger gain and less noise than the conventional tracking error signal TES'.

[0079] Here, the circuit unit 250 of Figure 14 may be connected to detect a tracking error signal from detection signals of the inner sectional plates A2, B2, C2 and D2.

[0080] The circuit unit 250 of Figure 14 may further include a time delay 240 at output ends of the outer sectional plates A1 and B1, as shown in Figure 15.

[0081] In this case, the detection signals a1 and b1 of the outer sectional plates A1 and B1 pass through the time delay 240 to then be converted into time-delayed signals a11 and b11, which are summed with the detection signals c1 and d1 of the outer sectional plates C1 and D1 positioned in another row to then be applied to the amplifier 260 and the phase comparator 251, like in Figure 14.

[0082] If the detection signals a1 and b1 of the outer sectional plates A1 and B1 positioned in one row are time-delayed to detect a track error signal TES, as shown in Figure 15, it is possible to compensate for a tracking error signal offset generated when an objective lens (not shown) is shifted due to a phase difference offset of diagonal sum signals, caused by a change in the pit depth, occurring to practical recording media, thereby detecting a more accurate tracking error signal.

[0083] In other words, if a difference in the pit depth of a recording medium is generated, the conventional tracking error signal detecting apparatus detects a tracking error signal by summing detection signals of two diagonal directions and then subtracting the diagonal sum signals. Thus, signal deterioration is severe. On the other hand, the circuit unit 250 of Figure 15 according to the present invention first performs an operation of detection signals of sectional plates positioned in the same diagonal line, and time-delay and amplification are then performed to produce a tracking error signal. Thus, since phase deterioration due to signal distortion caused by a change in the pit depth is greatly improved, a tracking error signal with greatly reduced offset can be generated.

[0084] Alternatively, unlike the circuit unit 250 according to another embodiment of the present invention, as shown in Figure 14, in which a tracking error signal is generated using only the detection signals of the inner or outer sectional plates, detection signals of both the inner and outer sectional plates A2, B2, C2 and D2 and A1, B1, C1 and D1 can be used in detecting a tracking error signal, as shown in Figure 16.

[0085] In other words, the circuit unit 250 may detect a tracking error signal by appropriately operating detection signals of sectional plates positioned in the respective diagonal directions, and phase-comparing the operation signals. The circuit unit 250 has the following configuration.

[0086] Detection signals a1, c1, a2 and c2 of the outer and inner sectional plates A1, C1, A2, C2 positioned in one diagonal direction are applied to a first operator 280. The first operator 280 amplifies a sum signal a2+c2 of detection signals a2 and c2 of the inner sectional plates A2 and C2 with a

predetermined gain k1 and adds a sum signal a1+c1 of detection signals a1 and c1 of the outer sectional plates A1 and C1 with the amplified signal k1(a2+c2).

[0087] The output signal a1+c1+k1(a2+c2) of the first operator 280 is again amplified by an amplifier 289 with a predetermined gain k2.

[0088] Detection signals b1, d1, b2 and d2 of the outer and inner sectional plates B1, D1, B2, D2 positioned in the other diagonal direction are applied to a second operator 285. The second operator 285 amplifies a sum signal b2+d2 of detection signals b2 and d2 of the inner sectional plates B2 and D2 with a predetermined gain k1 and adds a sum signal b1+d1 of detection signals b1 and d1 of the outer sectional plates B1 and D1 with the amplified signal k(b2+d2).

[0089] The output signal of the amplifier 289 and the output signal b1+d1+k(b2+d2) are applied to a phase comparator 251 to then be phase-compared. The phase comparator 251 outputs a tracking error signal TES.

[0090] Here, the gains k and k1 are constants, and the gain k2 is preferably a constant other than zero. Also, the sum k+k1 of the gains k and k1 is preferably a constant. If the gains k and k1 are both zero, the same result as shown in Figure 14 is caused.

[0091] The circuit unit 250 shown in Figure 16 may further include a time delay 240 at the output ends of the sectional plates A1, A2, B1 and B2 positioned in one row, as shown in Figure 17.

[0092] In this case, the detection signals a1, a2, b1 and b2 of the sectional plates A1, A2, B1 and B2 pass through the time delay 240 to then be converted into time-delayed signals a11, a22, b11 and b22, respectively. The time-delayed signals a11 and a22 and the detection signals c1 and c2 of the sectional plates C1 and C2 positioned in the diagonal direction thereof, and the time-delayed signals b11 and b22 and the detection signals d1 and d2 of the sectional plates D1 and D2 positioned in the diagonal direction thereof, are applied to the first and second operators 280 and 285, respectively, like in Figure 16.

[0093] The output signal a11+c1+k1x(a22+c2) of the first operator 280 is amplified by the amplifier 289 with a predetermined gain k2.

[0094] The output signal b11+d1+k1x(b22+d2) of the second operator 285 and the output signal k2x [a11+c1+k1x(a22+c2)] of the amplifier 289 are applied to the phase comparator 251 to then be phase-compared. The phase comparator 251 outputs a tracking error signal TES.

[0095] In the circuit unit 250 having the aforementioned configuration, like in Figure 15, signal distortion can be obscured by time delay and amplification even when there is a difference between pit depths of a recording medium. Thus, even in the case of a lens shift, a tracking error signal with greatly reduced offset can be generated.

[0096] In the case where the light spot deviates 0.1 mu m from the center of the pit or mark sequence recorded on the recording medium, the tracking error signals detected by the embodiments of the above-described tracking error signal detecting apparatus preferably have approximately 0.5 in the minimum value of DELTA t/Tw, where Tw represents a period of a channel clock of the recording/reproducing apparatus and DELTA t represents the detected average phase difference time, and preferably have approximately 0.2 in the maximum value of ¦(T1-T2)/(T1+T2)¦, where T1 represents the maximum value of the tracking error signal, which is a positive value, and T2 represent the minimum value of the tracking error signal, which is a negative value.

[0097] Also, in the embodiments of the above-described tracking error signal detecting apparatus, phase comparators are provided for phase-comparing input signals through selectively blocking or amplifying the input signals according to the frequency band, digitization, phase-comparison of digitized signals and integration of the phase-compared signals, and outputting tracking error signals

[0098] Figure 18 is a diagram schematically illustrating a reproduction signal detecting apparatus according to an embodiment of the present invention. The reproduction signal detecting apparatus includes an 8-sectional photodetector 30 and a circuit unit 300 for reproducing information of a recording medium from detection signals of the photodetector 30. Here, the photodetector 30 may be one of the 8-sectional photodetectors shown in Figures 4 through 8.

[0099] The circuit unit 300 for detecting a reproduction signal includes an amplifier 310 for amplifying a sum signal a1+b1+c1+d1 of detection signals a1, b1, c1 and d1 of outer sectional plates A1, B1, C1 and D1 of the photodetector 30 with a predetermined gain k, and an adder 350 for adding a sum signal

a2+b2+c2+d2 of detection signals a2, b2, c2 and d2 of inner sectional plates A2, B2, C2 and D2 of the photodetector 30 and an output signal of the amplifier 310, to then output a reproduction signal.

[0100] Here, the gain k is a value which is determined for maximizing the magnitude of the reproduction signal and minimizing the jitter and error ratio of the reproduction signal.

[0101] The circuit unit 300 may further include amplifiers AMP's for uniformly amplifying signals, between the amplifier 310 and the adder 350, and along the transmission path of the sum signal a2+b2+c2+d2 of detection signals a2, b2, c2 and d2 of inner sectional plates A2, B2, C2 and D2, and pre-equalizers for correcting phase distortion of signals. Otherwise, the circuit unit 300 may further an equalizer at the output end of the adder 350.

[0102] As described above, the reproduction signal detecting apparatus according to an embodiment of the present invention amplifies the sum signal a1+b1+c1+d1 of detection signals a1, b1, c1 and d1 of outer sectional plates A1, B1, C1 and D1 with a predetermined gain k and sums the amplified signal with the sum signal a2+b2+c2+d2 of detection signals a2, b2, c2 and d2 of inner sectional plates A2, B2, C2 and D2, to thus detect a reproduction signal.

[0103] Figure 19 is a diagram schematically illustrating a reproduction signal detecting apparatus according to another embodiment of the present invention. A circuit unit 300 according to this embodiment is featured by further including a time delay 340 for time-delaying detection signals a1, a2, b1 and b2 of sectional plates A1, A2, B1 and B2 positioned in one row of the photodetector 30.

[0104] The reproduction signal detecting apparatus according to another embodiment of the present invention amplifies a sum signal a11+b11+c1+d1 of time-delayed signals a11 and b11 of detection signals a1 and b1of outer sectional plates A1 and B1 and detection signals c1 and d1 of outer sectional plates C1 and D1 with a predetermined gain k, and sums the amplified signal with a sum signal a22+b22+c2+d2 of time-delayed signals a22 and b22 of detection signals a2 and b2 of inner sectional plates A2 and B2 and detection signals c2 and d2 of inner sectional plates C2 and D2, to thus detect a reproduction signal.

[0105] According to the reproduction signal detecting apparatus of the present invention described in Figures 18 and 19, during reproduction of a high-density recording medium having narrow tracks, it is possible to compensate for a phase difference due to a crosstalk between adjacent tracks of detection signals of inner sectional plates and detection signals of outer sectional plates, thereby detecting a reproduction signal with much less crosstalk than in the conventional reproduction signal detecting apparatus. In particular, during reproduction of a recording medium having a large difference in the pit depths, a crosstalk reducing effect can be enhanced by employing the reproduction signal detecting apparatus shown in Figure 19 configured to phase-delay detection signals of some sectional plates.

[0106] As described above, the tracking error signal detecting apparatus according to the present invention includes an 8-sectional photodetector the widths of which vary in a radial direction of the respective sectional plates so as to make full use of phase characteristics depending on light receiving regions, so that the detections signals of inner and outer sectional plates are operated in consideration of a difference in the phase characteristics. Therefore, a tracking error signal with a large gain and greatly reduced crosstalk between adjacent tracks can be detect. Also, phase deterioration due to signal distortion caused by a difference in pit depths can be greatly reduced by using time-delayed signals of the detection signals of some sectional plates. Thus, even when a lens shift occurs, a tracking error signal having little offset can be generated.

[0107] Therefore, the tracking error signal detecting apparatus according to the present invention can allow accurate tracking control in a high-density recording medium having relatively narrow tracks.

[0108] Also, the reproduction signal detecting apparatus according to the present invention can correct signal distortion due to a difference between phase characteristics of detection signals of inner and outer sectional plates of a photodetector even during reproduction of an information signal from a high-density recording medium having relatively narrow tracks, thereby detecting an improved reproduction signal with greatly reduced crosstalk.

[0109] Although the present invention has been described and illustrated in detail through specific embodiments, it is clearly understood that various modifications and changes may be effected within the scope of the invention.

[0110] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by

reference.

[0111] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0112] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0113] The invention is not restricted to the details of the foregoing embodiment(s). The invention extend to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Tracing-error signal detection device and regnerated signal detection apparatus

Claims of corresponding document: **EP1096481**

1. A tracking error signal detecting apparatus having a photodetector (30) for receiving light reflected/diffracted from a recording medium, and a circuit unit (50) for performing operations on detection signals of the photodetector and producing a tracking error signal, the apparatus characterized in that the photodetector includes four light receiving regions (30a-30d) arrayed counterclockwise, the dividing lines of which are substantially parallel to the radial and tangential directions of the recording medium, each of the four light receiving regions (30a-d) are further bisected to produce an inner sectional plate and an outer sectional plate, the radial widths of which vary along +/- tangential directions from the center of the photodetector (30), so that 8 inner and outer sectional plates arrayed in a 2 x 4 matrix are formed, the directions of columns and rows of the sectional plates corresponding to the radial and tangential directions of the recording medium, and that the circuit unit (50) compares the phases of the light receiving regions positioned in the same row and then produces a tracking error signal from a phase difference signal.

2. The tracking error detecting apparatus according to claim 1, wherein the circuit unit comprises:

a first phase comparator (51) for comparing phases of detection signals of a pair of outer sectional plates (A1, B1) positioned in one row and outputting a phase difference signal;
a second phase comparator (53) for comparing phases of detection signals of a pair of outer sectional plates (C1, D1) positioned in the other row and outputting a phase difference signal; and
an adder (59) for adding phase difference signals output from the first and second phase comparators (51, 53) and outputting a tracking error signal.

3. The tracking error detecting apparatus according to claim 1, wherein the circuit unit comprises:

a first phase comparator (151) for comparing phases of detection signals of a pair of inner sectional plates (A2, B2) positioned in one row and outputting a phase difference signal;
a second phase comparator (153) for comparing phases of detection signals of a pair of inner sectional plates (C2, D2) positioned in the other row and outputting a phase difference signal; and
an adder (159) for adding phase difference signals output from the first and second phase comparators and outputting the tracking error signal.

4. The tracking error detecting apparatus according to claim 1, wherein the circuit unit comprises:

first and second phase comparators (51, 151) for comparing phases of detection signals of a pair of outer (A1, B1) and inner (A2, B2)) sectional plates positioned in one row, respectively, and outputting phase difference signals;
third and fourth phase comparators (53, 153) for comparing phases of detection signals of a pair of outer (C1, D1) and inner (C2, D2) sectional plates positioned in the other row, respectively, and outputting phase difference signals;
a first adder (59) for adding the phase difference signals output from the first and third phase comparators (51, 53) to detect a first tracking error signal based on the detection signals of the outer sectional plates (A1, B1, C1, D1);
a second adder (159) for adding the phase difference signals output from the second and fourth phase comparators (151, 153) to detect a second tracking error signal based on the detection signals of the inner sectional plates (A2, B2, C2, D2); and
an operator (60) for summing the first and second tracking error signals detected by the first and second adders (59, 159) to output a tracking error signal.

5. The tracking error signal detecting apparatus according to claim 4, wherein the operator (60) amplifies at least one of the first and second tracking error signals output from the first and second adders (59, 159) with a predetermined gain to produce a tracking error signal.

6. The tracking error detecting apparatus according to claim 1, wherein the circuit unit (50) comprises:

a first operator (161) for amplifying a detection signal of one inner sectional plate (A2) positioned in one

row with a predetermined gain and adding the amplified signal and a detection signal of the corresponding outer sectional plate (A1);
a second operator (162) for amplifying a detection signal of the other inner sectional plate (B2) positioned in one row with a predetermined gain and adding the amplified signal and a detection signal of the corresponding outer sectional plate (B1);
a third operator (163) for amplifying a detection signal of one inner sectional plate (C2) positioned in the other row with a predetermined gain and adding the amplified signal and a detection signal of the corresponding outer sectional plate (C1);
a fourth operator (164) for amplifying a detection signal of the other inner sectional plate (D2) positioned in the other row with a predetermined gain and adding the amplified signal and a detection signal of the corresponding outer sectional plate (D1);
a first phase comparator (165) for comparing phases of sum signals output from the first and second operators (161, 163) and outputting a phase difference signal;
a second phase comparator (167) for comparing phases of sum signals output from the third and fourth operators (163, 164) and outputting a phase difference signal; and
an adder (169) for adding the phase difference signals output from the first and second phase comparators (165, 167) to output a tracking error signal.

7. The tracking error detecting apparatus according to any one of claims 1 through 6, wherein the inner sectional plates (A2, B2, C2, D2) are formed such that their widths are relatively narrower at the center of the photodetector (30) and relatively wider along +/- tangential directions.

8. The tracking error detecting apparatus according to claim 7, wherein the lines dividing the inner light receiving regions from the outer sectional plates (A1, B1, C1, D1) are curved lines.

9. The tracking error detecting apparatus according to claim 8, wherein the maximum width of each of the inner sectional plates (A2, B2, C2, D2) is larger than the radius of received 0th-order diffracted light.

10. The tracking error detecting apparatus according to claim 7, wherein the width of each of the inner sectional plates (A2, B2, C2, D2) linearly increases from the center of the photodetector (30) outward in the +/- tangential directions.

11. The tracking error detecting apparatus according to claim 10, wherein each of the inner sectional plates (A2, B2, C2, D2) has a shape selected from a trapezoid, a right-angle triangle and an isosceles triangle.

12. A tracking error signal detecting apparatus having a photodetector (30) for receiving light reflected/diffracted from a recording medium, and a circuit unit (250) for performing operations on detection signals of the photodetector (30) and producing a tracking error signal, the apparatus characterized in that the photodetector (30) includes four light receiving regions (30a-30d) arrayed counterclockwise, the dividing lines of which are substantially parallel to the radial and tangential directions of the recording medium, each of the four light receiving regions are further bisected to produce an inner sectional plate and an outer sectional plate, the radial widths of which vary along +/- tangential directions from the center of the photodetector (30), so that 8 inner and outer sectional plates arrayed in a 2 x 4 matrix are formed, the directions of columns and rows of the sectional plates corresponding to the radial and tangential directions of the recording medium, and that the circuit unit (250) amplifies at least some of the detection signals of the inner and/or outer sectional plates positioned in one diagonal direction with a predetermined gain, compares phase differences between the amplified signals and at least some of the detection signals of inner and/or outer sectional plates positioned in the other diagonal direction, and detects a tracking error signal from a phase difference signal.

13. The tracking error detecting apparatus according to claim 12, wherein the circuit unit comprises:

an amplifier (260) for amplifying a sum signal of detection signals of outer (A1, C1) or inner (A2, C2) sectional plates positioned in one diagonal direction with a predetermined gain; and
a phase comparator (251) for comparing phases of a sum signal of detection signals of outer (B1, D1) or inner (B2, D2) sectional plates positioned in the other diagonal direction to detect a tracking error signal.

14. The tracking error detecting apparatus according to claim 12, wherein the circuit unit (250) comprises:

a first operator (280) for receiving detection signals of inner and outer sectional plates (A1, A2, C1, C2) positioned in one diagonal direction, amplifying a sum signal of detection signals of the inner sectional plates (A2, C2) with a first predetermined gain and adding the amplified signal and a sum signal of

detection signals of the outer sectional plates (A1, C1);
a second operator (285) for receiving detection signals of inner and outer sectional plates (B1, B2, D1, D2) positioned in the other diagonal direction, amplifying a sum signal of detection signals of the inner sectional plates (B2, D2) with a second predetermined gain and adding the amplified signal and a sum signal of detection signals of the outer sectional plates (B1, D1);
an amplifier (289) for amplifying a signal output from one of the first and second operators (280, 285) with a third predetermined gain; and
a phase comparator (251) for comparing phases of a signal output from the other of the first and second operators (280, 285) and a signal output from the amplifier (289) to produce a tracking error signal.

15. The tracking error detecting apparatus according to claim 14, wherein the sum of the first and second predetermined gains is a constant value.

16. The tracking error detecting apparatus according to any one of claims 13 through 15, wherein the circuit unit further comprises a time delay (240) for time-delaying detection signals of the inner and/or outer sectional plates positioned in one row.

17. The tracking error detecting apparatus according to any one of claims 12 through 15, wherein the inner sectional plates (A2, B2, C2, D2) are formed such that their widths are relatively narrower at the center of the photodetector and relatively wider along +/- tangential directions.

18. The tracking error detecting apparatus according to claim 17, wherein the lines dividing the inner light receiving regions from the outer sectional plates are curved lines.

19. The tracking error detecting apparatus according to claim 18, wherein the maximum width of each of the inner sectional plates is larger than the radius of received 0th-order diffracted light.

20. The tracking error detecting apparatus according to claim 17, wherein the width of each of the inner sectional plates (A2, B2, C2, D2) linearly increases from the center of the photodetector (30) outward in the +/- tangential directions.

21. The tracking error detecting apparatus according to claim 20, wherein each of the inner sectional plates (A2, B2, C2, D2) has a shape selected from a trapezoid, a right-angle triangle and an isosceles triangle.

22. A reproduction signal detecting apparatus having a photodetector (30) for receiving light reflected/diffracted from a recording medium, and a circuit unit (300) for performing operations on detection signals of the photodetector (30) and producing a reproduction signal, the apparatus characterized in that the photodetector (30) includes four light receiving regions (30a-30d) arrayed counterclockwise, the dividing lines of which are substantially parallel to the radial and tangential directions of the recording medium, each of the four light receiving regions (30a-30d) are further bisected to produce an inner sectional plate and an outer sectional plate, the radial widths of which vary along +/- tangential directions from the center of the photodetector (30), so that 8 inner and outer sectional plates arrayed in a 2 x 4 matrix are formed, the directions of columns and rows of the sectional plates corresponding to the radial and tangential directions of the recording medium, and that the circuit unit (300) comprises:

an amplifier (310) for amplifying a sum signal of detection signals of the outer sectional plates (A1, B1, C1, D1); and
an adder (350) for adding a sum signal of detection signals of the inner sectional plates (A2, B2, C2, D2) and the output signal of the amplifier.

23. The reproduction signal detecting apparatus according to claim 22, wherein the circuit unit further comprises a time delay for time-delaying detection signals of the inner and/or outer sectional plates positioned in one row.

24. The reproduction signal detecting apparatus according to claim 22 or 23, wherein the respective light receiving regions are bisected such that the width of each of the inner sectional plates linearly increases from the center of the photodetector outward in the +/- tangential directions.

[19]中华人民共和国国家知识产权局

[51]Int. Cl⁷
G11B 7/00
G11B 7/09 G11B 21/10

[12]发明专利申请公开说明书

[21]申请号 00134725.X

R5

[43]公开日 2001年6月20日

[11]公开号 CN 1300054A

[22]申请日 2000.10.30 [21]申请号 00134725.X

[30]优先权

[32]1999.10.30 [33]KR [31]47750/1999

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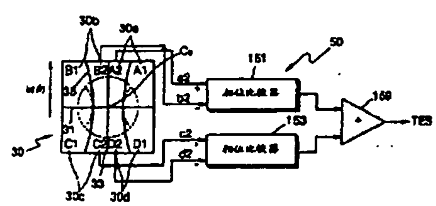
权利要求书5页 说明书13页 附图页数13页

[54]发明名称 跟踪误差信号检测装置和再生信号检测装置

[57]摘要

一种跟踪误差信号检测装置，通过对一个具有内侧和外侧分区板的8分 区光电探测器的改进，改善了因增益特性和/或凹槽间深度差异而造成的偏 移，各分区板的径向宽度从光电探测器的中心沿±切向不同，因而能够对窄 道高密度记录载体进行精确的跟踪控制。以及一种再生信号检测装置，在窄 道高密度记录载体的信息再生期间，能够校正因光电探测器内侧和外侧分区 板检测信号的相位特性差异造成的信号失真，从而降低串音噪声。



ISSN 1008-4274

权 利 要 求 书

1. 一种跟踪误差信号检测装置，包括一个光电探测器，用于接收从一记录载体反射/衍射的光，还包括一电路单元，用于对所述光电探测器的检测信号进行运算以产生一跟踪误差信号，其特征在于：所述光电探测器包括四个按逆时针方向排列的光接收区，光接收区的分界线实际上平行于记录载体的径向和切向，四个光接收区的每一区又被一分为二而形成一个内侧分区板和一个外侧分区板，其各自的径向宽度从光电探测器的中心沿着±切向各不相同，因而，8 个内侧和外侧分区板按 2×4 矩阵方式排布，所述分区板行和列的方向与记录载体的径向和切向一致，所述电路单元对位于相同行的光接收区的相位进行比较，并根据相位差信号产生一跟踪误差信号。

2. 根据权利要求 1 所述的跟踪误差信号检测装置，其特征在于，所述电路单元包括：

第一相位比较器，用于对位于一行的一对外侧分区板的检测信号进行相位比较，并输出一相位差信号；

第二相位比较器，用于对位于另一行的一对外侧分区板的检测信号进行相位比较，并输出一相位差信号；

一加法器，用于将第一和第二相位比较器输出的相位差信号相加并输出所述跟踪误差信号。

3. 根据权利要求 1 所述的跟踪误差信号检测装置，其特征在于，所述电路单元包括：

第一相位比较器，用于对位于一行的一对内侧分区板的检测信号进行相位比较，并输出一相位差信号；

第二相位比较器，用于对位于另一行的一对内侧分区板的检测信号进行相位比较，并输出一相位差信号；

一加法器，用于将第一和第二相位比较器输出的相位差信号相加并输出所述跟踪误差信号。

4. 根据权利要求 1 所述的跟踪误差信号检测装置，其特征在于，所述电路单元包括：

第一和第二相位比较器，用于分别对位于一行的一对内侧和一对外侧分区板的检测信号进行相位比较，并输出一相位差信号；

第三和第四相位比较器，用于分别对位于另一行的一对内侧和一对外侧分区板的检测信号进行相位比较，并输出一相位差信号；

第一加法器，用于将第一和第三相位比较器所输出的相位差信号相加并产生一基于外侧分区板检测信号的第一跟踪误差信号；

第二加法器，用于将第二和第四相位比较器所输出的相位差信号相加并产生一基于内侧分区板检测信号的第二跟踪误差信号；

一运算放大器，用于将第一和第二加法器输出的第一和第二跟踪误差信号相加，并输出所述跟踪误差信号。

5. 根据权利要求 4 所述的跟踪误差信号检测装置，其特征在于，所述运算放大器将从第一和第二加法器输出的第一和第二跟踪误差信号至少其中之一乘以一预定的放大系数进行放大以输出所述跟踪误差信号。

6. 根据权利要求 1 所述的跟踪误差信号检测装置，其特征在于，所述电路单元包括：

第一运算放大器，用于将位于一行的一个内侧分区板的检测信号乘以一预定的放大系数进行放大，并将该放大信号与同行相应的一外侧分区板的检测信号进行相加；

第二运算放大器，用于将位于一行的另一个内侧分区板的检测信号乘以一预定的放大系数进行放大，并将该放大信号与同行相应的一外侧分区板的检测信号进行相加；

第三运算放大器，用于将位于另一行的一个内侧分区板的检测信号乘以一预定的放大系数进行放大，并将该放大信号与同行相应的一外侧分区板的检测信号进行相加；

第四运算放大器，用于将位于另一行的另一个内侧分区板的检测信号乘以一预定的放大系数进行放大，并将该放大信号与同行相应的一外侧分区板的检测信号进行相加；

第一相位比较器，用于将从第一和第二运算放大器输出的和信号进行相位比较，并输出一相位差信号；

第二相位比较器，用于将从第三和第四运算放大器输出的和信号进行相位比较，并输出一相位差信号；

一加法器，用于将第一和第二相位比较器所输出的相位差信号相加并输出所述跟踪误差信号。

7. 根据权利要求 1 至 6 任一项所述的跟踪误差信号检测装置，其特征在于，所述的内侧分区板这样设置：在所述光电探测器的中心其宽度相对较窄，而沿±切向相对较宽。

8. 根据权利要求 7 所述的跟踪误差信号检测装置，其特征在于，所述的将内侧光接收区与外侧分区板分开的分界线为曲线。

9. 根据权利要求 8 所述的跟踪误差信号检测装置，其特征在于，所述的每一内侧分区板的最大宽度大于所接收到的第 0 级衍射光的半径。

10. 根据权利要求 7 所述的跟踪误差信号检测装置，其特征在于，所述的每一内侧分区板的宽度，从所述光电探测器的中心向外沿±切线方向线性增加。

11. 根据权利要求10所述的跟踪误差信号检测装置，其特征在于，所述的每一内侧分区板的形状可以选自梯形，直角三角形和等腰三角形。

12. 一种跟踪误差信号检测装置，包括一个光电探测器，用于接收从一记录载体反射/衍射的光，还包括一电路单元，用于对所述光电探测器的检测信号进行运算以产生一跟踪误差信号，其特征在于：所述光电探测器包括四个按逆时针方向排列的光接收区，光接收区的分界线实际上平行于记录载体的径向和切向，四个光接收区的每一区又被一分为二而形成一个内侧分区板和一个外侧分区板，其各自的径向宽度从光电探测器的中心沿着±切向各不相同，因而，8 个内侧和外侧分区板按 2×4 矩阵方式排布，所述分区板行和列的方向与记录载体的径向和切向一致；而且，所述电路单元将位于一对角线方向的内侧和/或外侧分区板的检测信号中的至少之一乘以一预定的放大系数进行放大，并将该放大信号与位于另一对角线方向的内侧和/或外侧分区板的检测信号中的至少之一进行相位比较，并根据相位差信号输出一跟踪误差信号。

13. 根据权利要求12所述的跟踪误差信号检测装置，其特征在于，所述的电路单元包括：

一放大器，用于将位于一对角线方向的外侧或内侧分区板的检测信号的和信号以一预定的放大系数进行放大；

一相位比较器，用于对位于另一对角线方向的外侧或内侧分区板的检测信号的和信号进行相位比较，并输出一跟踪误差信号。

14. 根据权利要求12所述的跟踪误差信号检测装置，其特征在于，所述

的电路单元包括：

第一运算放大器，用于接收位于一对角线方向的内侧和外侧分区板的检测信号，将该内侧分区板检测信号的和信号以一预定的第一放大系数进行放大，并将所述放大信号与该外侧分区板检测信号的和信号相加；

第二运算放大器，用于接收位于另一对角线方向的内侧和外侧分区板的检测信号，将该内侧分区板检测信号的和信号以一预定的第二放大系数进行放大，并将所述放大信号与该外侧分区板检测信号的和信号相加；

一放大器，用于将从第一和第二运算放大器之一输出的信号以一预定的第三放大系数进行放大；

一相位比较器，用于将上述第一和第二运算放大器中的另一输出信号与上述放大器所输出的放大信号进行相位比较，并产生所述的跟踪误差信号。

15．根据权利要求14所述的跟踪误差信号检测装置，其特征在于，所述的第一和第二预定放大系数的和为一常数。

16．根据权利要求13至15任一项所述的跟踪误差信号检测装置，其特征在于，所述的电路单元还包括一延时器，用于对位于同一行的内侧和/或外侧分区板的检测信号进行延时。

17．根据权利要求12至15任一项所述的跟踪误差信号检测装置，其特征在于，所述的内侧分区板这样设置：在所述光电探测器的中心其宽度相对较窄，而沿±切向相对较宽。

18．根据权利要求17所述的跟踪误差信号检测装置，其特征在于，所述的将内侧光接收区与外侧分区板分开的分界线为曲线。

19．根据权利要求18所述的跟踪误差信号检测装置，其特征在于，所述的每一内侧分区板的最大宽度大于所接收到的第0级衍射光的半径。

20．根据权利要求17所述的跟踪误差信号检测装置，其特征在于，所述的每一内侧分区板的宽度，从所述光电探测器的中心向外沿±切线方向线性增加。

21．根据权利要求20所述的跟踪误差信号检测装置，其特征在于，所述的每一内侧分区板的形状可以选自梯形，直角三角形和等腰三角形。

22．一种再生信号检测装置，包括一个光电探测器，用于接收从一记录载体反射/衍射的光，还包括一电路单元，用于对所述光电探测器的检测信号进行运算以产生一再生信号，其特征在于：所述光电探测器包括四个按逆

时针方向排列的光接收区，光接收区的分界线实际上平行于记录载体的径向和切向，四个光接收区的每一区又被一分为二而形成一个内侧分区板和一个外侧分区板，其各自的径向宽度从光电探测器的中心沿着±切向各不相同，因而，8 个内侧和外侧分区板按 2×4 矩阵方式排布，所述分区板行和列的方向与记录载体的径向和切向一致，所述电路单元包括：

一放大器，用于将外侧分区板的检测信号的和信号进行放大；

一加法器，用于将内侧分区板的检测信号的和信号与上述放大器的输出信号相加。

23. 根据权利要求22所述的再生信号检测装置，其特征在于，所述的电路单元还包括一延时器，用于对位于同一行的内侧和/或外侧分区板的检测信号进行延时。

24. 根据权利要求22或23所述的再生信号检测装置，其特征在于，所述的各光接收区被一分为二，以使每一内侧分区板的宽度从所述光电探测器的中心向外沿±切线方向线性增加。

说　明　书

跟踪误差信号检测装置和再生信号检测装置

本发明涉及一种跟踪误差信号检测装置和一种再生信号检测装置，更具体地说涉及一种用于提高检测跟踪误差信号精确性的跟踪误差信号检测装置，以及一种用于检测串音噪声被极大地降低了的再生信号的再生信号检测装置。

通过接收一光学拾取装置的光源所发射并被一光盘所反射的光而检测跟踪误差的传统的方法包括一种通过差分相位检测法（DPD）检测跟踪误差信号（TES）的方法。

参见图 1，照射到只读存储器（ROM）型光盘上的光被反射，并被记录标志如凹槽（P）衍射成第 0 级最大值和第±1 级最大值。当通过光学拾波器被传播回去之后，光电探测器 1 上接收到的光实际上包括在径向被第±1 级最大值重叠的第 0 级最大值。于是，对于一种具有窄道的高密度光盘，如一种被称作 HD－DVD 的第二代数字化通用光盘（DVD），这时，第 0 级最大值和第±1 级最大值是重叠的，而第+1 级最大值和第–1 级最大值彼此互不重叠。

第 0 级最大值与第+1 级最大值相重叠的部分和第 0 级最大值与第–1 级最大值相重叠的部分的相位信号与仅有第 0 级最大值部分的相位信号具有不同的特性。因此，对于具有窄道的高密度光盘，如果使用一种常用的 DPD 法（在该方法中对角分区板 A/C 和 B/D 的检测信号被减去）来检测跟踪误差信号时，由于在邻道间存在串音而在跟踪误差信号中产生很大的噪声。

为了检测邻道间因存在串音噪声而被降低的跟踪误差信号，人们已经提出一种方法，该方法采用一个 8 分区光电探测器20，如图 2 所示。

该 8 分区光电探测器20的每一行被分成 4 部分，各部分相应于盘的径向，每一列被分成 2 部分，各部分相应于盘的切线方向。这样，它的各个分区便被设置在一个 2×4 的阵列中。这时，各 2-分区板 A1/A2、B1/B2、C1/C2 和 D1/D2 分别相应于图 1 所示的光电探测器20的各分区板 A，B，C 和 D，分区板 A2、B2、C2 和 D2 分别位于 A1、B1、C1 和 D1 的内侧。

通过按下述方式检测光电探测器20的 8 个分区检测信号，获得跟踪误差

信号。

参见图3，位于对角线方向的外侧分区板A1和C1的检测信号a1和c1的和信号（a1+c1），以及将位于内侧分区板A2和C2的检测信号a2和c2的和信号（a2+c2）乘以一预定的放大系数k1放大而生成一信号，将这两信号相加，得到的和信号[a1+c1+k1(a2+c2)]被输出到放大器21，并以一预定的放大系数k2被放大。同样地，位于另一对角线方向的外侧分区板B1和D1的检测信号b1和d1的和信号（b1+d1）与将位于内侧分区板B2和D2的检测信号b2和d2的和信号（b2+d2）乘以一预定的放大系数k放大而生成的信号相加。之后，放大器21输出的信号[k2(a1+c1+k1(a2+c2))]以及对角分区板B1、B2、D1和D2输出的运算信号[b1+d1+k(b2+d2)]，被传送到一相位比较器25进行相位比较，然后，生成一跟踪误差信号TES′。

这里，假如k=k1=0而k2=1，则传送到相位比较器25的信号是a1+c1和b1+d1，这时出现这样一种情况，即通过对角线方向设置的外侧分区板的检测信号的和信号得到一相位差。

假如k≠0且k1≠0，则传送到相位比较器25的信号是a2+c2和b2+d2，这时出现这样一种情况，即通过对角线方向设置的内侧分区板的检测信号的和信号而得到相位差。

因为相位差是这样得到的：通过有选择性地对内侧分区板A2、B2、C2和D2的检测信号乘以一预定的放大系数而放大，之后，将放大信号和外侧分区板A1、B1、C1和D1的检测信号相加，所以按照上述的跟踪误差信号检测装置能够产生降低了串音噪声的跟踪误差信号。

虽然，传统的跟踪误差信号检测装置在一定程度上降低了串音噪声，但是，当应用于具有窄道且切向相位特性含糊的高密度盘时，其跟踪误差信号的增益是很低的，简而言之，其精确性是很差的。

位于记录道切线方向不同位置的分区板接收到的光束，在一记录标志如凹槽的起始区域和终止区域具有不同的相位特性。假如对角相邻分区板的检测信号象传统的跟踪误差信号检测装置那样被相加的话，则切向相位特性被偏移，因而其跟踪误差信号增益很低，也就是说，精确性很差。

同样，在传统的跟踪误差信号检测装置中，由于使用的是对角相邻分区板的检测信号的和信号，因为凹槽间的深度是各不相同的，和信号之间的相位差是偏移的。因此，假如移动物镜（未示出），则跟踪误差信号会产生一

较大的偏移量。

有鉴于此，提出了本发明。本发明的一个发明目的是提供一种跟踪误差信号检测装置，通过采用一分区结构改进了的8分区光电探测器，以此来改善因记录道凹槽的深度不同而造成的增益特性改变和/或偏移；以及提供一种降低了串音噪声的再生信号检测装置。

为了达到上述目的，本发明的一种跟踪误差信号检测装置包括一个用于接收记录载体反射光/衍射光的光电探测器，还包括一个电路单元，用以对光电探测器的检测信号进行运算以生成一跟踪误差信号。该装置的特征在于，上述光电探测器包括按逆时针方向排列的四个光接收区，其分界线实际上平行于记录载体的径向和切向，四个光接收区的每一区又被一分为二以形成一内侧分区板和一外侧分区板，从光电探测器的中心沿±切向，各自的径向宽度不同，因而，按一个2×4矩阵方式形成了8个内侧和外侧分区板，分区板的列和行的方向分别与记录载体的径向和切向一致。电路单元比较位于相同行的光接收区的相位，并从一相位差信号生成一跟踪误差信号。

另一方面，本发明的电路单元将位于对角线方向的内侧和/或外侧分区板的检测信号中的至少一些信号以一预定的放大系数进行放大，将该放大信号与位于另一对角线方向的内侧和/或外侧分区板的检测信号中的至少一些信号进行相位差比较，并根据一相位差信号检测出一跟踪误差信号。

最好内侧分区板的宽度在光电探测器的中心相对较窄，而沿±切线方向相对较宽。

例如，将内侧光接收区与外侧分区板分开的分界线最好是曲线，每一内侧分区板的最大宽度最好大于接收到的第0级衍射光的半径。

同样，为了实现本发明的上述发明目的，再生信号检测装置可包括一个用于接收记录载体反射光/衍射光的光电探测器，以及一个用于对光电探测器的探测信号进行运算以生成一再生信号的电路单元，该光电探测器包括按逆时针方向排列的四个光接收区，其分界线实际上平行于记录载体的径向和切向，四个光接收区的每一区又被一分为二以形成一内侧分区板和一外侧分区板，从光电探测器的中心沿±切线方向，各自的径向宽度发生变化，因而，按2×4矩阵方式形成了8个内侧和外侧分区板，分区板的列和行的方向分别与记录载体的径向和切向一致。电路单元包括一个放大器，用于将外侧分区板的检测信号的和信号进行放大；以及一个加法器，用于将内侧分区板的

检测信号的和信号与上述放大器的输出信号相加。

另一方面，本发明的电路单元还可以包括一个延时器，用于对相同行的内侧和/或外侧分区板的检测信号进行延时产生延时检测信号。

本发明的上述目的及优点将通过结合附图对本发明的实施例的详细描述而得到进一步说明。

图1为一透视图，示出检测记录载体反射/衍射光的现有技术；

图2和3示出一采用传统8分区光电探测器的跟踪误差信号检测装置；

图4为一框图，示出符合本发明一个实施例的跟踪误差信号检测装置；

图5至图8为平面图，示出图4所示光电探测器的其他实例；

图9为一曲线图，示出从图4所示跟踪误差信号检测装置所输出的跟踪误差信号；

图10为一曲线图，示出从传统的跟踪误差信号检测装置所输出的跟踪误差信号；

图11至13为方框图，示出图4所示电路单元的其他实例；

图14为一框图，示意地表明根据本发明的跟踪误差信号检测装置的另一个实施例；

图15至17为方框图，示出图14所示电路单元的其他实例；

图18为一框图，示出符合本发明的一个实施例的再生信号检测装置；

图19为一框图，示出符合本发明另一个实施例的再生信号检测装置。

图4给出了一个符合本发明一个实施例的跟踪误差信号检测装置，它包括一个光电探测器30，用于接收被一记录载体如光盘（图1的10）的反射/衍射光；以及包括一电路单元50，用于对光电探测器30的检测信号进行运算以产生一跟踪误差信号TES。这里，光电探测器30接收从记录载体反射的入射光，产生检测信号用于检测跟踪误差信号TES和检测记录载体的再生信号，这将在下面描述。

光电探测器30包括按2×2矩阵方式沿逆时针方向排列的四个光接收区30a（A1/A2）、30b（B1/B2）、30c（C1/C2）和30d（D1/D2），光接收区如此设置，以便光电探测器30能够沿着与记录载体的切向一致的方向被一分为二，且又沿着与记录载体的径向一致的方向被一分为二，其中的切向是指记录载体上信息记录顺序的方向，而径向是指垂直于信息记录顺序的方向。各自的光接收区30a、30b、30c和30d被一分为二从而具有内侧分区板A2、B2、

C2 和 D2，其各自的径向宽度从光电探测器30的中心 C_0 沿±切向各不相同。

这样，光电探测器30按 2×4 矩阵方式排布，包含 8 个分区板 A1、A2、B1、B2、C1、C2、D1 和 D2，各自独立实现光电转换。其中的外侧分区板 A1、B1、C1 和 D1 及内侧分区板 A2、B2、C2 和 D2 按逆时针方向排列。

如图 2 所示，从一具有相对窄道的 ROM 型高密度记录载体所反射/衍射的光，被衍射成沿径向的第 0 级衍射光和第±1 级衍射光。当第 0 级衍射光和第±1 级衍射光重叠，而第+1 级衍射光和第−1 级衍射光不重叠时，外侧分区板 A1、B1、C1 和 D1 接收主要来自第 0 级衍射光和第+1 级衍射光的重叠区域以及来自第 0 级衍射光和第−1 级衍射光的重叠区域的光，而内侧分区板 A2、B2、C2 和 D2 仅仅接收来自第 0 级衍射光区域的光。

换句话说，内侧分区板 A2、B2、C2 和 D2 的宽度最好设置成这样，即在光电探测器30的中心 C_0 其宽度相对较窄，而沿±切向变得较宽。

然而，对于一种具有相对较大道间距的低密度记录载体或者具有平台/凹槽（land/groove）结构的 RAM 型高密度记录载体，从记录载体反射/衍射光的一部分第±1 级衍射光同时与第 0 级衍射光重叠，各光接收区30a、30b、30c 和30d 最好被一分为二而形成内侧分区板 A2、B2、C2 和 D2，其宽度在光电探测器30的中心 C_0 相对较宽，而沿±切向变得较窄。这时，内侧分区板 A2、B2、C2 和 D2 接收来自第 0 级衍射光与第±1 级衍射光同时重叠的区域的光。

本发明所述的 8 分区光电探测器30的分区结构将通过下文的实施例子以详细说明。如图 4 和 5 所示，各光接收区30a、30b、30c 和30d 的每区分界线 35 最好是一具有预定曲率的曲线，以便分别接收来自第 0 级衍射光区域及来自第 0 级衍射光与第±1 级衍射光的重叠区域的光。

这时，分界线35与第 0 级衍射光和第±1 级衍射光的重叠区域相切，切点在分界线35与行方向分界线31的交叉点处。

图 4 所示的分界线35实质上是椭圆的一部分，图 5 所示的分界线35是抛物线的一部分，如此设置，是为了使每个内侧分区板 A2、B2、C2 和 D2 的最大宽度大于在该处接收到的第 0 级衍射光的半径。图 5 所示的分界线35更加接近于第 0 级衍射光和第±1 级衍射光的重叠区域的边界线，这样作的优点是，能够将在外侧分区板 A1、B1、C1 和 D1 接收到的第 0 级衍射光数量减少到最少程度。

或者，各光接收区30a、30b、30c 和30d 也可这样被一分为二，使得每一内侧分区板 A2、B2、C2 和 D2 的宽度，从光电探测器30的中心 C_0 向外在±切线方向线性增加。

例如，各光接收区30a、30b、30c 和30d 可这样被一分为二，使得每一内侧分区板 A2、B2、C2 和 D2 具有梯形，直角三角形或者等腰三角形的形状，它们与光电探测器30的中心 C_0 相距一预定的距离，并在±切线方向向外延伸，如图 6 至 8 所示。

如上所述，符合本发明的一个实施例的跟踪误差信号检测装置，其包括一个可具有不同分区形状的 8 分区光电探测器30，下面将以具有如图 4 所示分区形状的光电探测器30为例进行描述。

参见图 4，电路单元50将位于相同行的内侧和/或外侧分区板的检测信号的相位进行相互比较，并根据相位差信号产生一跟踪误差信号。

例如，如图 4 所示，电路单元50包括一对相位比较器51和53，用于比较输入信号的相位，还包括一个加法器59，用于将从相位比较器51和53输出的相位差信号相加。

位于第一行的外侧分区板 A1 和 B1 的检测信号 a1 和 b1 被输入给相位比较器51进行相位比较。位于第二行的外侧分区板 C1 和 D1 的检测信号 c1 和 d1 被输入给相位比较器53进行相位比较。

从而，通过将位于相同行的外侧分区板 A1 和 B1 的检测信号 a1 和 b1 之间的相位差信号与位于相同行的外侧分区板 C1 和 D1 的检测信号 c1 和 d1 之间的相位差信号进行相加，从加法器59输出一跟踪误差信号 TES，也就是说，在切向方向上相同的行，相位差信号被分别从相位比较器51和53输出而得到。

图 9 所示为一曲线图，根据如图 4 所示的本发明的一个实施例的跟踪误差信号检测装置，曲线示出了从装置的电路单元50所输出的跟踪误差信号 TES；图10所示为一曲线图，示出了由如图 2 和 3 所示的传统的跟踪误差信号检测装置所产生的跟踪误差信号 TES′。图中，横坐标表示在径向移动横穿记录载体各道的光点位置，纵坐标表示因光点的移动而形成的跟踪误差信号的变化。

比较图 9 和图10，与图 10 相比，由本发明的跟踪误差信号检测装置检测到的跟踪误差信号 TES 与 TES′ 相比具有较大的增益并且显著地改善了

串音噪声特性。TES' 指由传统的光电探测器（图 2 的20）的外侧分区板 A1、B1、C1 和 D1 的检测信号 a1、b1、c1 和 d1 而得到对角和信号 a1+c1 和 b1+d1，然后通过比较其相位产生的跟踪误差信号 TES'。

图11所示为电路单元50的另一实施例，其跟踪误差信号是使用内侧分区板 A2、B2、C2 和 D2 的检测信号 a2、b2、c2 和 d2 而得到的，取代了由外侧分区板 A1、B1、C1 和 D1 的检测信号 a1、b1、c1 和 d1 来获得。

换言之，位于第一行的内侧分区板 A2 和 B2 的检测信号 a2 和 b2 被输入给相位比较器151，从而输出一相位差信号。同样地，位于第二行的内侧分区板 C2 和 D2 的检测信号 c2 和 d2 被输入给相位比较器153，从而输出一相位差信号。一加法器159将二相位差信号相加而输出一跟踪误差信号。

图12所示为电路单元50的另一实施例，它具有图 4 和图11所示结构的复合结构，其利用所有内侧和外侧分区板 A1、A2、B1、B2、C1、C2、D1 和 D2 的检测信号 a1、a2、b1、b2、c1、c2、d1 和 d2 来产生一跟踪误差信号。

换言之，通过对外侧分区板 A1、B1、C1 和 D1 的检测信号 a1、b1、c1 和 d1 进行运算而获得一跟踪误差信号 TES1（见图 9），通过对内侧分区板 A2、B2、C2 和 D2 的检测信号 a2、b2、c2 和 d2 进行运算而获得一跟踪误差信号 TES2，TES1 和 TES2 被一运算放大器60相加而产生一跟踪误差信号 TES。这里，TES2 是通过对内侧分区板 A2、B2、C2 和 D2 的检测信号 a2、b2、c2 和 d2 进行运算而获得的跟踪误差信号，与如图11所示的从加法器159输出的跟踪误差信号一致。

运算放大器60将从加法器59和159输出的跟踪误差信号 TES1 和 TES2 中的一跟踪误差信号 TES2 乘以一预定的放大系数 k 进行放大，然后，将另一跟踪误差信号 TES1 与放大信号 k×TES2 相加而产生一跟踪误差信号 TES=[TES1+（k×TES2）]。

这里，运算放大器60也可以将跟踪误差信号 TES1 乘以一预定的放大系数进行放大。或者，运算放大器60也可以将跟踪误差信号 TES1 和 TES2 两者都乘以合适的放大系数进行放大并将放大信号相加而得到一跟踪误差信号 TES。

另外如图13所示的电路单元50，它可以包括第一至第四运算放大器161、162、163和164，第一和第二相位比较器165和167以及一加法器169，这样也可以产生一跟踪误差信号。首先，将内侧分区板 A2、B2、C2 和 D2 的检测

信号 a2、b2、c2 和 d2 乘以一预定的放大系数 k 进行放大而得到信号 ka2、kb2、kc2 和 kd2，然后，将相应的外侧分区板 A1、B1、C1 和 D1 的检测信号 a1、b1、c1 和 d1 与之相加而得到和信号 a1+ka2、b1+kb2、c1+kc2 和 d1+kd2，再将和信号进行相位比较，将相位差信号相加。

将第一行上的外侧和内侧分区板 A1 和 A2 的检测信号 a1 和 a2 输入给第一运算放大器161。第一运算放大器161将内侧分区板 A2 的检测信号 a2 乘以一预定的放大系数 k 进行放大并与外侧分区板 A1 的检测信号 a1 相加。因此，第一运算放大器161的输出信号为 a1+ka2。

同样地，其它光接收区 B1 和 B2、C1 和 C2、D1 和 D2 的检测信号 b1 和 b2、c1 和 c2、d1 和 d2 分别被输入给第二至第四运算放大器162、163和164并进行运算。第二至第四运算放大器162、163和164输出运算信号 b1+kb2、c1+kc2 和 d1+kd2。

被位于第一行的光接收区 A1 和 A2 及 B1 和 B2 检测到且已通过第一和第二运算放大器161和162运算的信号，被第一相位比较器165进行相位比较。同样，被位于第二行的光接收区 C1 和 C2 及 D1 和 D2 检测到且已通过第三和第四运算放大器163和164的信号，被第二相位比较器167进行相位比较。

从第一和第二相位比较器165和167输出的相位差信号被加法器169相加。之后，加法器169输出跟踪误差信号 TES。

具有上述结构的电路单元50，将形成各自光接收区 30a、30b、30c 和 30d 的外侧和内侧分区板的检测信号与通过将内侧分区板的检测信号乘以一预定放大系数而获得的信号进行相加，并将来自相同行分区板的信号的相位差进行比较。因而，在外侧和内侧分区板的检测信号之间的信号特性的差别被补偿，因此，能够以较大的增益和较低的串音噪声来产生跟踪误差信号。

图14示出符合本发明另一个实施例的跟踪误差信号检测装置，其中的电路单元250，将位于一对角线方向的内侧和/或外侧分区板的至少一些检测信号乘以一预定的放大系数进行放大，再将上述放大信号与位于另一对角线方向的内侧和/或外侧分区板的至少一些检测信号进行相位比较，根据相位差信号而产生一跟踪误差信号。

例如，如图14所示，电路单元250包括一放大器260，用以将位于一对角线方向的外侧分区板 A1 和 C1 的检测信号 a1 和 c1 的和信号放大，还包括一相位比较器251，用以将位于另一对角线方向的外侧分区板 B1 和 D1 的检

测信号 b1 和 d1 的和信号 b1+d1 与放大器260的输出信号 k2(a1+c1)进行相位比较，这样产生一跟踪误差信号 TES。这里，放大系数 k2 是一不为零的常数。

上述的跟踪误差信号检测装置，与一般的 DPD 法相似，将位于一对角线方向的外侧分区板的检测信号相加。然而，该装置仅仅接收来自外侧分区板的第 0 级最大值和第+1 级最大值及第 0 级最大值和第–1 级最大值的重叠区域的光，将一对角线方向的和信号乘以一放大系数进行放大，然后，将上述放大信号的相位与另一对角线方向的和信号的相位进行比较。因而，跟踪误差检测信号 TES 比传统的跟踪误差检测信号 TES'具有更大的增益系数和更低的噪声。

图 14 所示的电路单元250可以连接从内侧分区板 A2、B2、C2 和 D2 输出的检测信号来产生一跟踪误差信号。

如图15所示，图 14 所示的电路单元250还可以包括一延时器240，所述延时器被连接在外侧分区板 A1 和 B1 的输出端。

这时，外侧分区板 A1 和 B1 的检测信号 a1 和 b1 通过延时器240后被转换成延时信号 a11 和 b11，分别与另一行的外侧分区板 C1 和 D1 的检测信号 c1 和 d1 相加，然后象图 14 那样，输入给放大器260和相位比较器251。

假如位于同一行的外侧分区板 A1 和 B1 的检测信号 a1 和 b1 被延时以检测跟踪误差信号 TES，如图15所示，在物镜（未示出）因对角和信号的相位差偏移而被移动产生偏移时，有可能能够补偿跟踪误差信号的偏移。由于实际的记录载体上的凹槽深度的改变可以引起所述对角和信号的相位差偏移，因此此装置可以产生一更加精确的跟踪误差信号。

换言之，假如一记录载体的凹槽深度发生变化，则传统的跟踪误差信号检测装置是通过将二对角线方向的检测信号相加并减去对角和信号来产生跟踪误差信号的，所以，信号衰减是很严重的。另一方面，图15所示的本发明的电路单元250，首先将位于同一对角线的分区板的检测信号检出，然后进行延时和放大以生成一跟踪误差信号。因而，由于凹槽深度的变化引起的信号失真而导致的相位衰减便得到很大的改善，从而获得偏移量被极大地降低了的跟踪误差信号。

或者，不象图14所示的本发明的另一实施例的电路单元250那样仅仅利用内侧或外侧分区板的检测信号来产生跟踪误差信号，而是如图16所示，利

用内侧和外侧分区板 A2、B2、C2 和 D2 和 A1、B1、C1 和 D1 两者的检测信号来产生一跟踪误差信号。

换言之，电路单元250可以通过将位于各自对角线的分区板的检测信号进行适当的运算，并对运算信号进行相位比较，来产生一跟踪误差信号。该电路单元250具有如下的结构。

位于一对角线的外侧和内侧分区板 A1、C1、A2、C2 的检测信号 a1、c1、a2 和 c2 被输入给第一运算放大器280。第一运算放大器280将内侧分区板 A2 和 C2 的检测信号 a2 和 c2 的和信号 a2+c2 乘以一预定的放大系数 k1 进行放大，并将外侧分区板 A1 和 C1 的检测信号的和信号 a1+c1 与放大信号 k1(a2+c2) 相加。

第一运算放大器280的输出信号 a1+c1+k1(a2+c2)再被放大器289以一预定的放大系数 k2 进行放大。

位于另一对角线的外侧和内侧分区板 B1、D1、B2、D2 的检测信号 b1、d1、b2 和 d2 被输入给第二运算放大器285。第二运算放大器285将内侧分区板 B2 和 D2 的检测信号 b2 和 d2 的和信号 b2+d2 乘以一预定的放大系数 k 进行放大，并将外侧分区板 B1 和 D1 的检测信号的和信号 b1+d1 与放大信号 k(b2+d2)相加。

放大器289的输出信号和上述输出信号 b1+d1+k(b2+d2)被输入给相位比较器251进行相位比较。相位比较器251输出跟踪误差信号 TES。

这里，系数 k 和 k1 是常数，系数 k2 最好是一不为零的常数。而且，系数 k 和 k1 的和 k+k1 最好是一常数。假如系数 k 和 k1 都是零，便得到了与图14所示相同的结果。

如图17所示，图16所示的电路单元250还可以包括一延时器240，所述延时器被连在同一行的分区板 A1、A2、B1 和 B2 的输出端。

这时，分区板 A1、A2、B1 和 B2 的检测信号 a1、a2、b1 和 b2 经过延时器240后被分别转换成延时信号 a11、a22、b11 和 b22。延时信号 a11 和 a22 与位于相同对角线的分区板 C1 和 C2 的检测信号 c1 和 c2，以及，延时信号 b11 和 b22 与位于相同对角线的分区板 D1 和 D2 的检测信号 d1 和 d2，分别被输入给第一和第二运算放大器280和285，如图17所示。

第一运算放大器280的输出信号 a11+c1+k1×(a22+c2)又被放大器289以一预定的放大系数 k2 进行放大。

第二运算放大器285的输出信号 b11+d1+k1×(b22+d2)和放大器289的输出信号 k2×[a11+c1+k1×(a22+c2)]均被输入给相位比较器251，并进行相位比较。相位比较器251输出跟踪误差信号 TES。

具有上述结构的电路单元250，如图15所示，即使当一记录载体的凹槽深度发生变化时，通过延时和放大处理，其信号的失真也可以被克服。因而，即使在物镜移动的情况下，也能够产生一偏移量大大降低的跟踪误差信号。

当光点从记录在记录载体上的记录标志顺序(mark sequence)或者凹槽的中心偏离 0.1μm 时，被上述实施例中的跟踪误差信号检测装置检测到的跟踪误差信号，其Δt/Tw 的最小值最好约为 0.5，其中 Tw 表示记录/再生装置的通道时钟(channel clock)周期，Δt 表示被检测到的平均相位差时间，而且|(T1－T2) / (T1+T2) |的最大值最好约为 0.2，其中 T1 表示跟踪误差信号的最大值，为正值，T2 表示跟踪误差信号的最小值，为负值。

而且，在上述实施例中的跟踪误差信号检测装置上，相位比较器的作用在于：根据输入信号的频带、数字化、数字化信号的相位比较和相位比较信号的集成情况，使其选择性地被抑制(blocking)或者被放大，对输入信号进行相位比较，并输出跟踪误差信号。

图18为一框图，示意地表明符合本发明一个实施例的再生信号检测装置。再生信号检测装置包括一个 8 分区光电探测器30和一电路单元300，用于根据光电探测器30的检测信号形成记录载体的再生信息。这里，光电探测器30可以是图 4 至 8 所示的任一种 8 分区光电探测器。

用于检测再生信号的电路单元300包括一放大器310，用于将光电探测器30的外侧分区板 A1、B1、C1 和 D1 的检测信号 a1、b1、c1 和 d1 的和信号 a1+b1+c1+d1 以一预定的系数 k 进行放大；还包括一加法器350，用于将光电探测器30的内侧分区板 A2、B2、C2 和 D2 的检测信号 a2、b2、c2 和 d2 的和信号 a2+b2+c2+d2 与放大器310的输出信号相加，之后输出一再生信号。

其中，系数 k 的值根据以下情况决定：使再生信号的幅度最大、失真度最小和错误率最小。

电路单元300还可以包括放大器 AMP，设计在放大器310和加法器350之间，用于连接内侧分区板 A2、B2、C2 和 D2 的检测信号 a2、b2、c2 和 d2 的和信号 a2+b2+c2+d2 的传输通道，将信号均一地放大；还可以包括一前置均衡器，用于校正信号的相位失真。另外，电路单元300还可以在加法器350

的输出端设计一补偿电路。

如上所述，按照本发明一个实施例的再生信号检测装置，将外侧分区板 A1、B1、C1 和 D1 的检测信号 a1、b1、c1 和 d1 的和信号 a1+b1+c1+d1 以一预定的系数 k 进行放大，并将该放大信号与内侧分区板 A2、B2、C2 和 D2 的检测信号 a2、b2、c2 和 d2 的和信号 a2+b2+c2+d2 相加，从而输出再生信号。

图19为一框图，示意地表明符合本发明另一个实施例的再生信号检测装置。按照该实施例，电路单元300的特征在于还进一步包括一延时器340，用于将光电探测器30的相同行分区板 A1、A2、B1 和 B2 的检测信号 a1、a2、b1 和 b2 延时。

本发明另一实施例的再生信号检测装置，将外侧分区板 A1 和 B1 的检测信号 a1、b1 的延时信号 a11 和 b11 与外侧分区板 C1 和 D1 的检测信号 c1 和 d1 相加得到的和信号 a11+b11+c1+d1，以一预定的系数 k 进行放大，并将该放大信号与内侧分区板 A2 和 B2 的检测信号 a2、b2 的延时信号 a22 和 b22 和内侧分区板 C2 和 D2 的检测信号 c2 和 d2 和信号 a22+b22+c2+d2 相加，从而输出再生信号。

如图18和19所示，本发明的再生信号检测装置，在具有窄道高密度记录载体的信号再生期间，因在内侧分区板的检测信号和外侧分区板的检测信号的邻道之间的串音而引起的相位差，有可能被得以补偿，因而，检测出的再生信号比传统的再生信号检测装置具有更少的串音。特别是，在凹槽深度差异很大的记录载体的再生期间，通过设置具有如图19所示结构的再生信号检测装置，将某些分区板的检测信号进行相位延时处理，可以大大降低串音的影响。

如上所述，本发明的跟踪误差信号检测装置包括一 8 分区光电探测器，其各自分区板的径向宽度互不相同以便充分利用依赖于光接收区的相位特性，这样，由于相位特性存在差异，对内侧和外侧分区板的检测信号分别进行运算。因此，可以获得具有较大增益系数和相邻道间串音被大大降低的跟踪误差信号。同样，通过对一些分区板的检测信号延时，因凹槽深度差异形成的信号失真而导致的相位衰减也会大大降低。这样，即使物镜发生移动，具有很小偏移量的跟踪误差信号也可以得到。

所以，本发明的跟踪误差信号检测装置能够对具有相对窄道的高密度记

录载体实行精确的跟踪控制。

同样，本发明的再生信号检测装置，即使在具有相对窄道的高密度记录载体的信息信号的再生期间，也能够对因光电探测器内侧和外侧分区板的检测信号的相位特性之间的差异而造成的信号失真予以校正，从而获得一大大降低了串音的改善的再生信号。

虽然，通过具体实施例已经对本发明进行了详细地描述和说明，但是，应当知道，在本发明的范围内，可以进行不同的修改和变化。

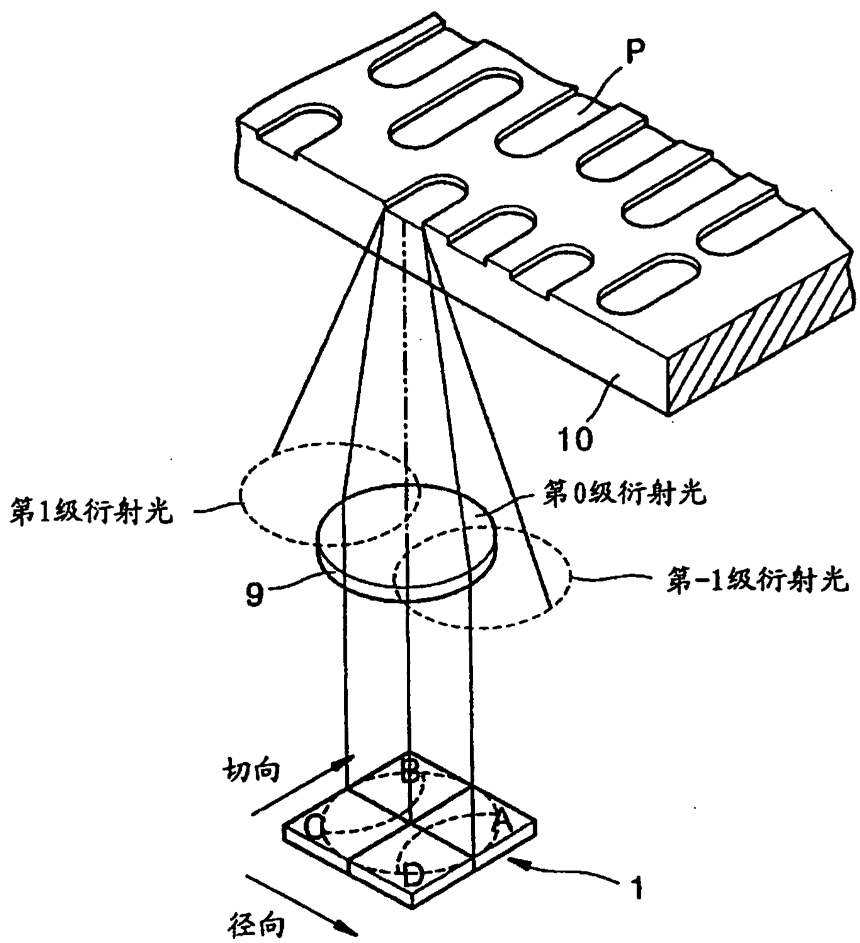


图 1

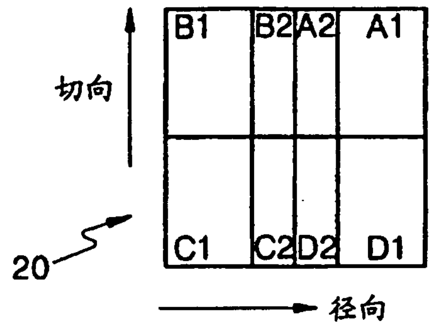

B1
B2
A2
A1
切向
C1
C2
D2
D1
20
径向

图 2

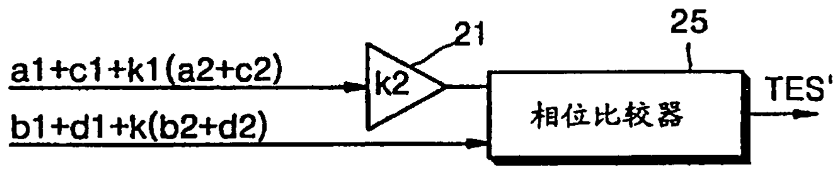

a1+c1+k1(a2+c2)
b1+d1+k(b2+d2)
k2
21
25
相位比较器
TES'

图 3

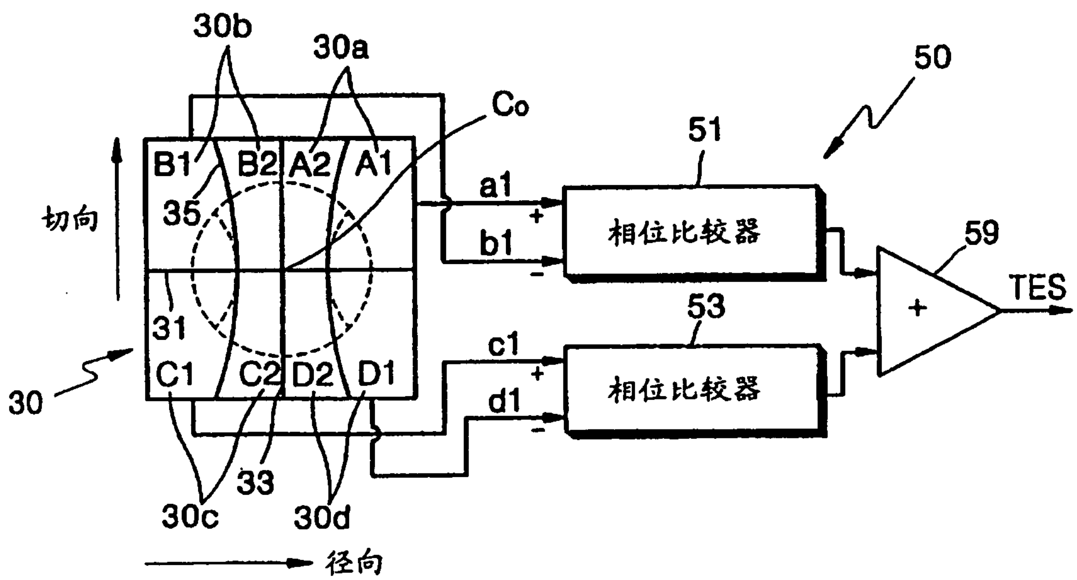

30b
30a
Co
50
51
B1
B2
A2
A1
35
切向
a1
b1
相位比较器
59
31
53
TES
C1
C2
D2
D1
c1
d1
相位比较器
30
33
30c
30d
径向

图 4

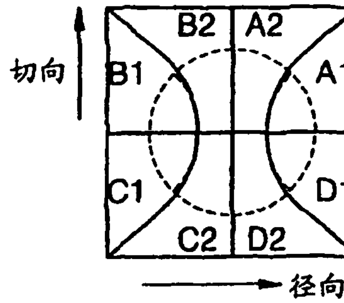

切向
B2
A2
B1
A1
C1
D1
C2
D2
径向

图 5

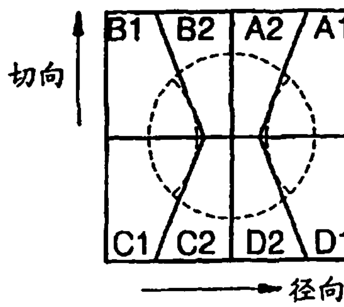

切向
B1
B2
A2
A1
C1
C2
D2
D1
径向

图 6

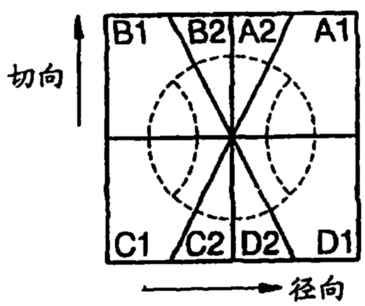

切向
B1
B2
A2
A1
C1
C2
D2
D1
径向

图 7

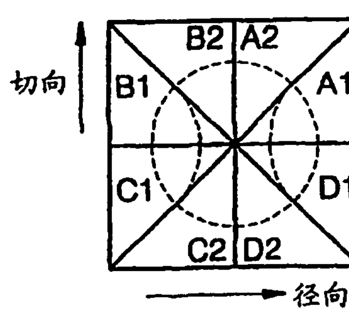

切向
B2
A2
B1
A1
C1
D1
C2
D2
径向

图 8

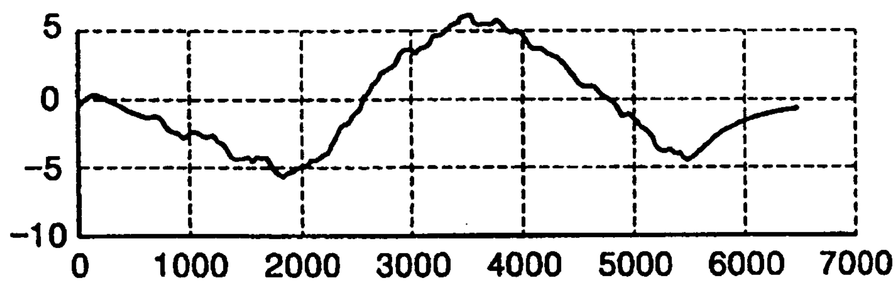

5
0
−5
−10
0
1000
2000
3000
4000
5000
6000
7000

图 9

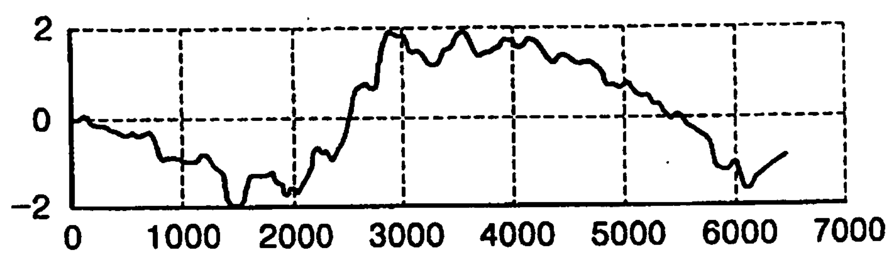

2
0
−2
0
1000
2000
3000
4000
5000
6000
7000

图 10

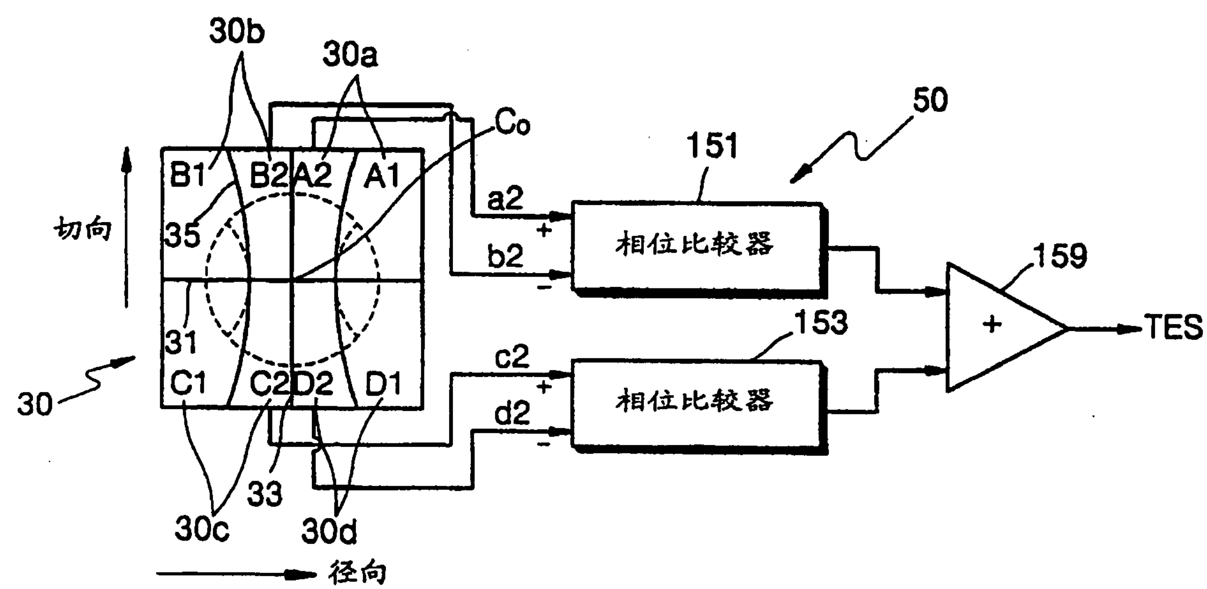

30b
30a
Co
50
151
B1
B2
A2
A1
a2
b2
切向
35
相位比较器
159
+
TES
31
153
c2
d2
30
C1
C2
D2
D1
相位比较器
33
30c
30d
径向

图 11

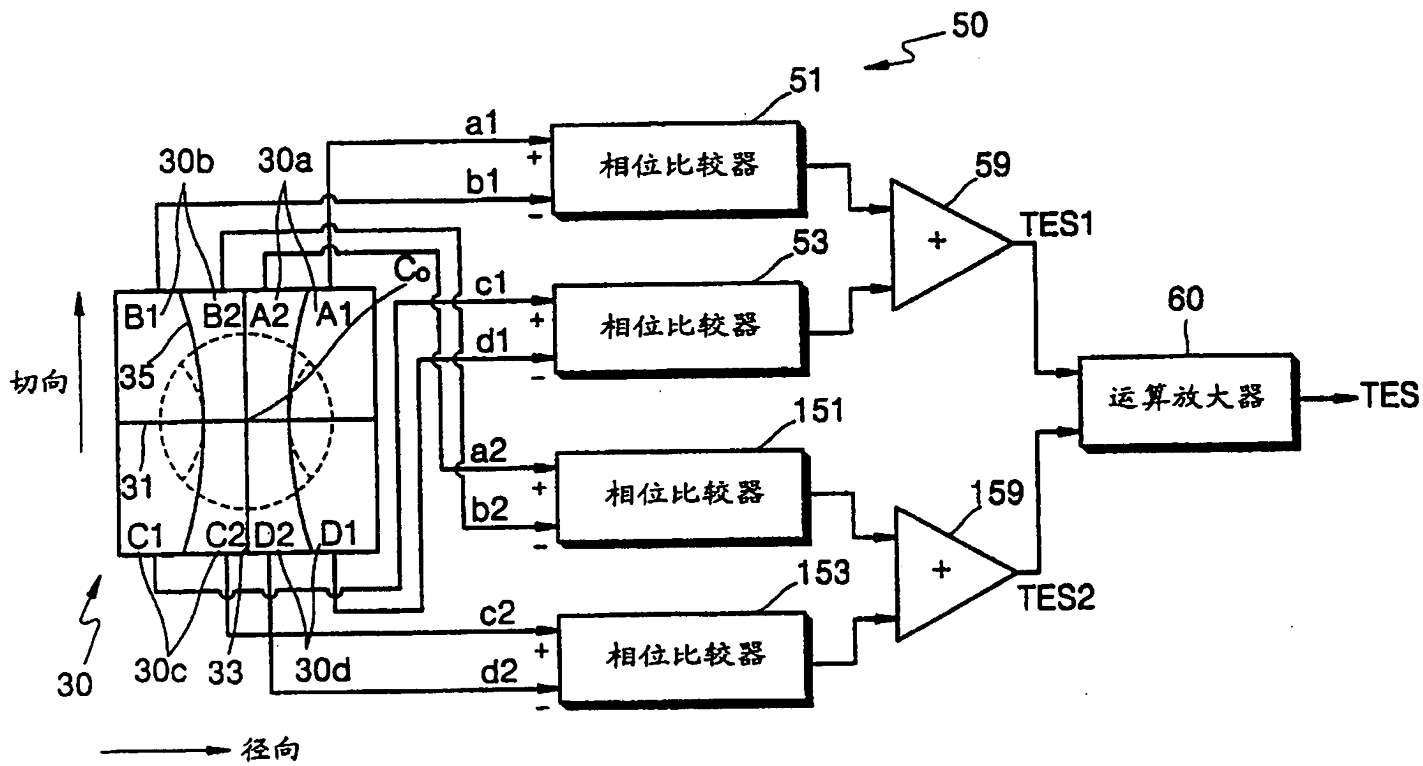

50
51
53
151
153
59
159
60
a1
b1
c1
d1
a2
b2
c2
d2
相位比较器
相位比较器
相位比较器
相位比较器
TES1
TES2
运算放大器
TES
30b
30a
B1
B2
A2
A1
Co
35
31
C1
C2
D2
D1
30
30c
33
30d
切向
径向

图 12

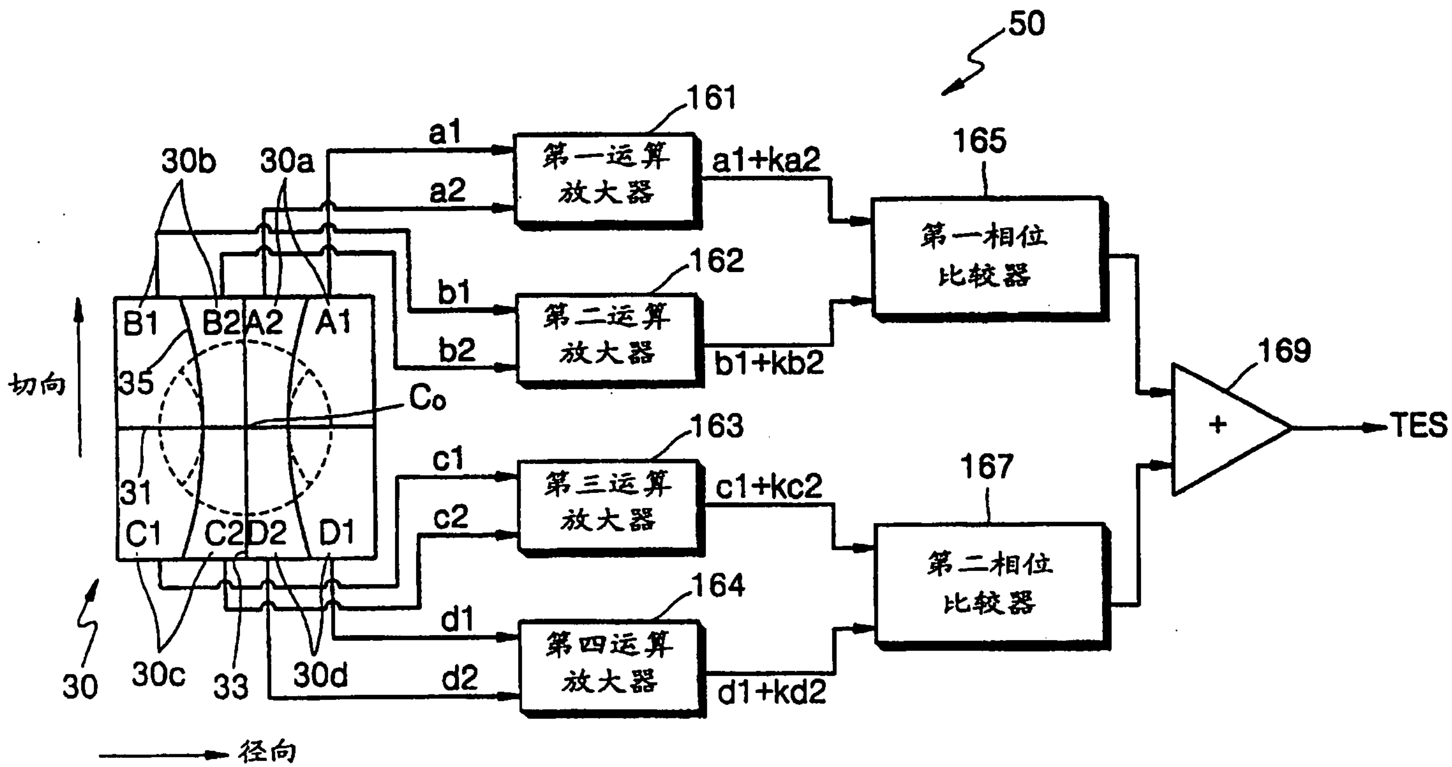
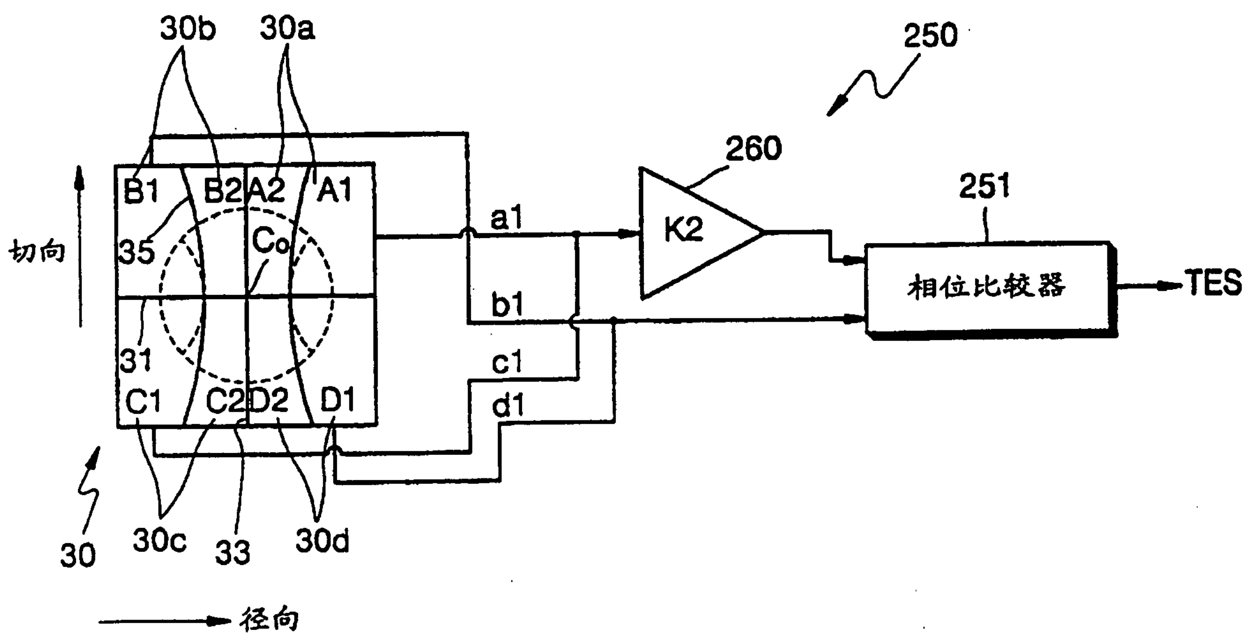

50
161
162
163
164
165
167
169
30b
30a
30c
33
30d
30
B1
B2
A2
A1
35
Co
31
C1
C2
D2
D1
切向
径向
a1
a2
b1
b2
c1
c2
d1
d2
第一运算放大器
第二运算放大器
第三运算放大器
第四运算放大器
a1+ka2
b1+kb2
c1+kc2
d1+kd2
第一相位比较器
第二相位比较器
+
TES

图 13



30b
30a
250
260
251
B1
B2
A2
A1
切向
35
Co
K2
a1
相位比较器
TES
b1
31
c1
C1
C2
D2
D1
d1
30
30c
33
30d
径向

图 14

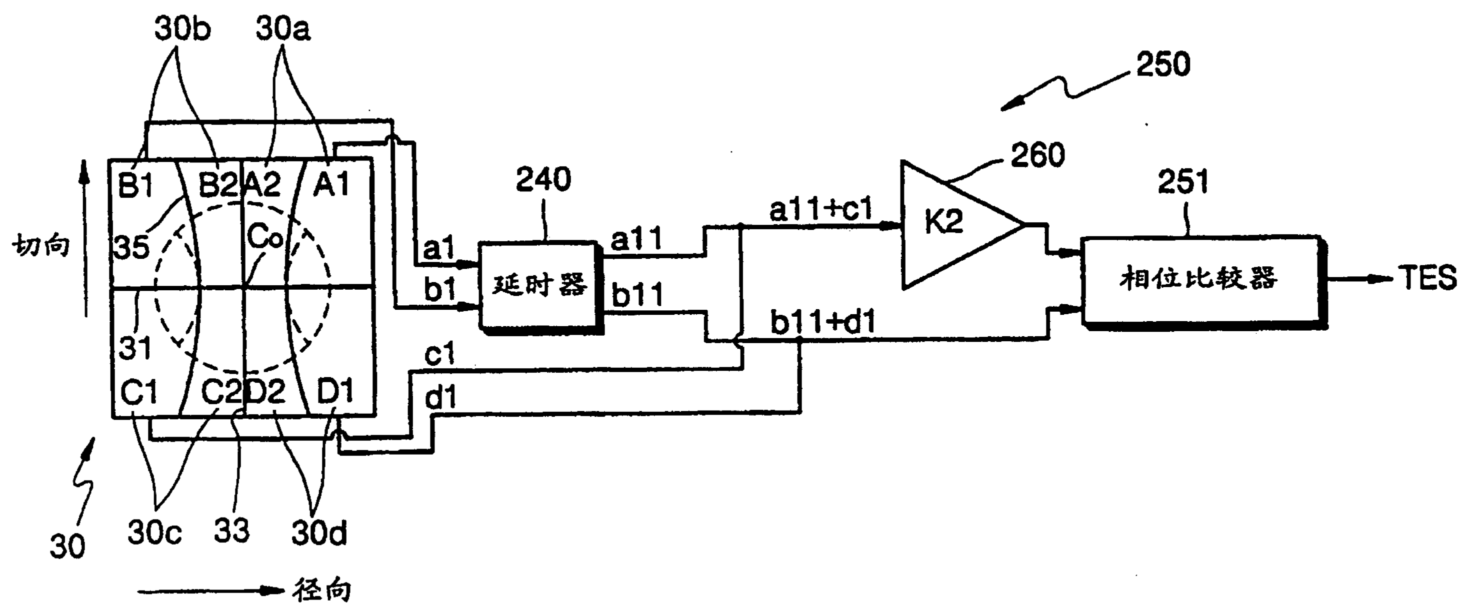
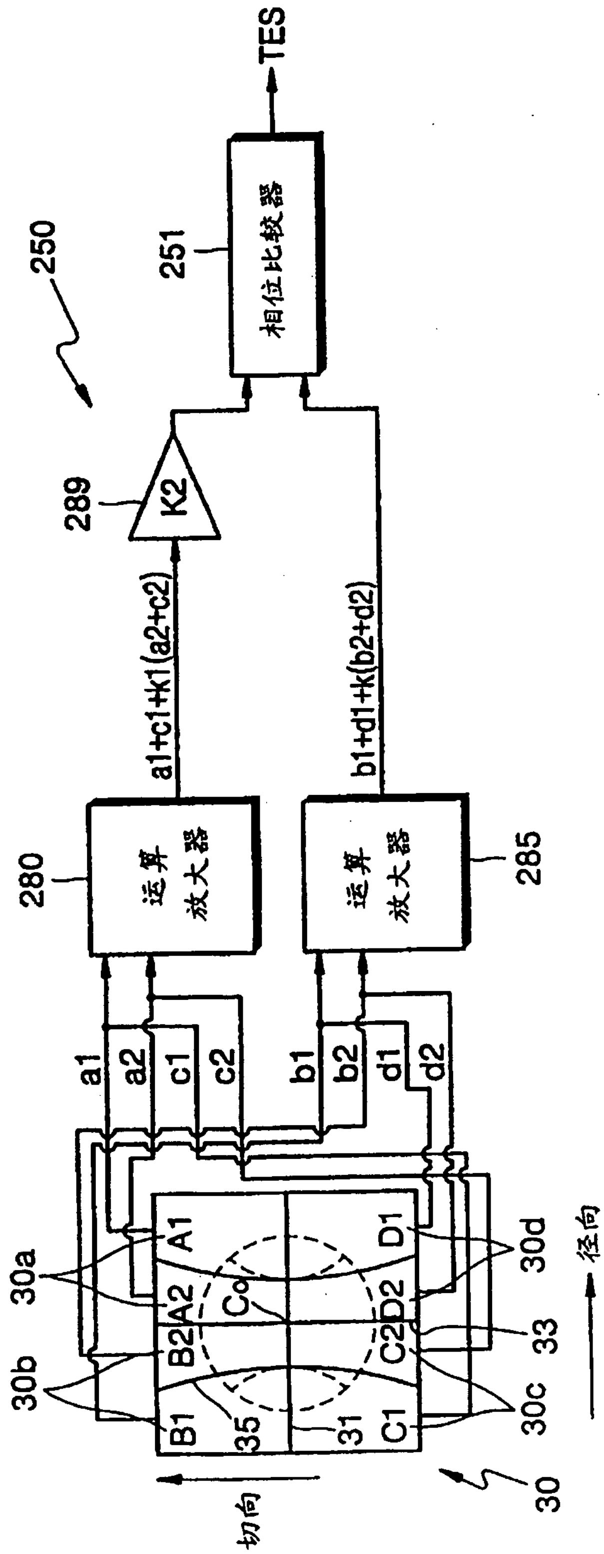

30b
30a
250
260
251
240
B1
B2
A2
A1
切向
35
Co
a1
延时器
a11
a11+c1
K2
相位比较器
TES
b1
b11
b11+d1
31
c1
C1
C2
D2
D1
d1
30
30c
33
30d
径向

图 15



250
251
相位比较器
TES
289
K2
a1+c1+K1(a2+c2)
b1+d1+K(b2+d2)
280
运算
放大器
285
运算
放大器
a1
a2
c1
c2
b1
b2
d1
d2
30a
30b
30c
30d
A1
A2
B1
B2
C1
C2
D1
D2
Co
33
35
31
30
切向
径向

图 16

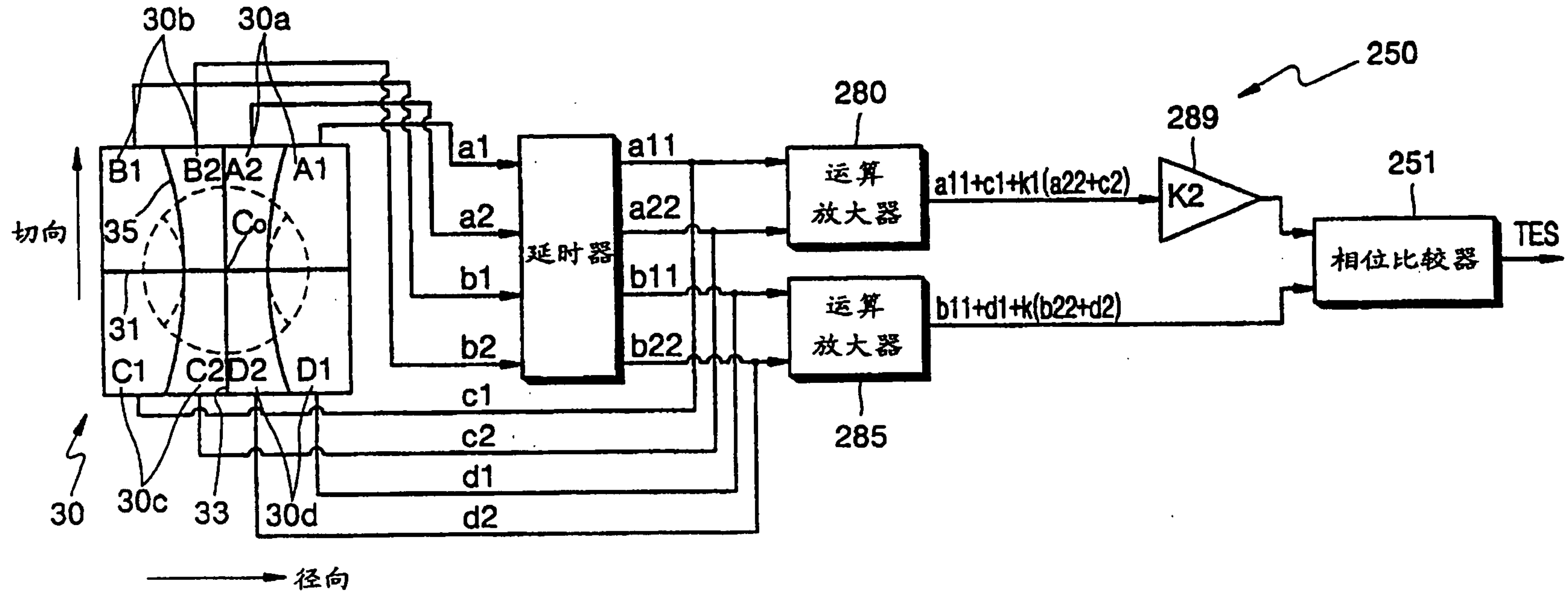

30b
30a
B1
B2
A2
A1
35
Co
31
C1
C2
D2
D1
切向
径向
30
30c
33
30d
a1
a2
b1
b2
c1
c2
d1
d2
延时器
a11
a22
b11
b22
280
运算
放大器
285
a11+c1+k1(a22+c2)
b11+d1+k(b22+d2)
289
K2
250
251
相位比较器
TES

图 17

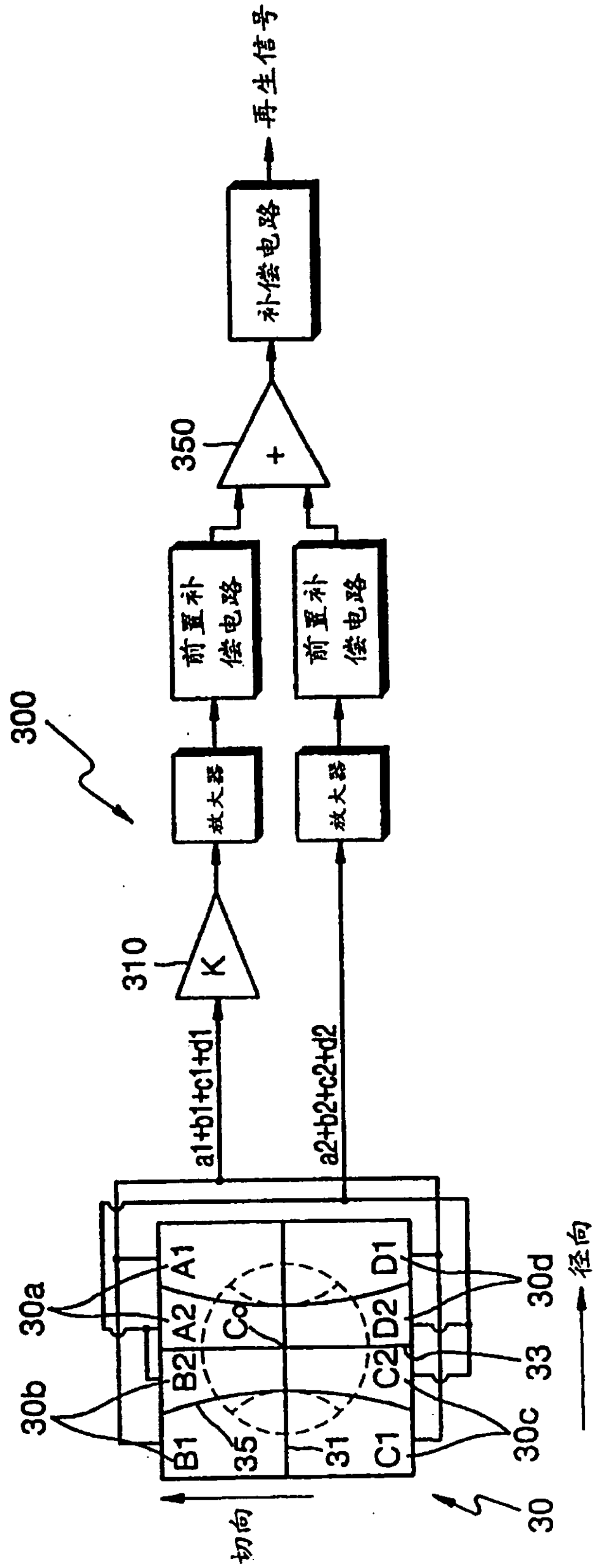

再生信号
补偿电路
350
+
前置补偿电路
前置补偿电路
300
放大器
放大器
310
K
a1+b1+c1+d1
a2+b2+c2+d2
30a
30b
A1
A2
B2
B1
Co
35
31
D1
D2
C2
C1
30d
33
30c
30
切向
径向

图 18

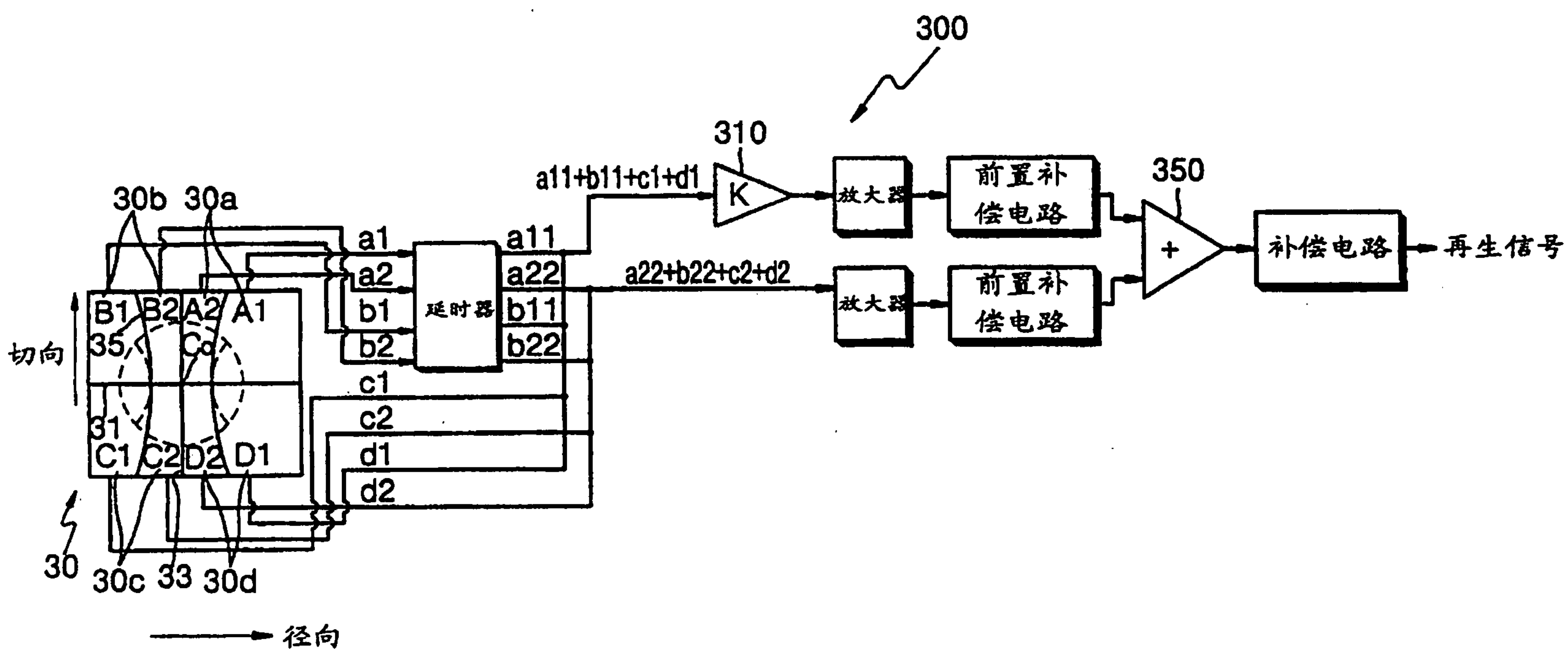

300
310
350
a11+b11+c1+d1
a22+b22+c2+d2
K
+
放大器
放大器
前置补偿电路
前置补偿电路
补偿电路
再生信号
延时器
a1
a2
b1
b2
c1
c2
d1
d2
a11
a22
b11
b22
30b 30a
B1 B2 A2 A1
35
Co
31
C1 C2 D2 D1
切向
30
30c 33 30d
径向

图 19